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"The FOUNDRYMEN'S OWN MAGAZINE"

November 1945 — Pattern Redesign (p. 25). Steel Castings Repair Methods (p. 29). Density of Castings (p. 38). Influence of Radiation on Metal Freezing Rate (p. 45). Molecular Sand Control (p. 49). Cast Iron Practice (p. 57).

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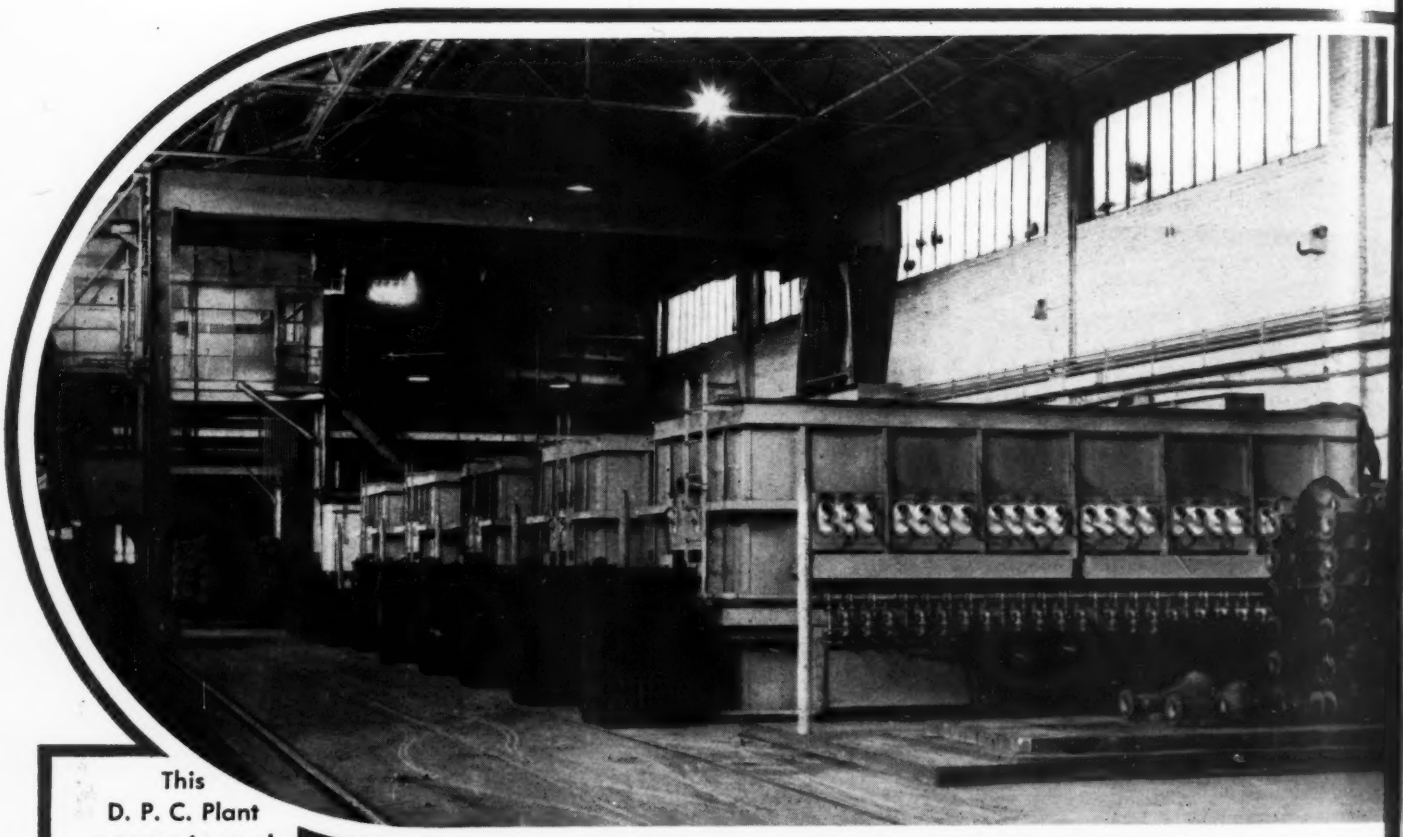

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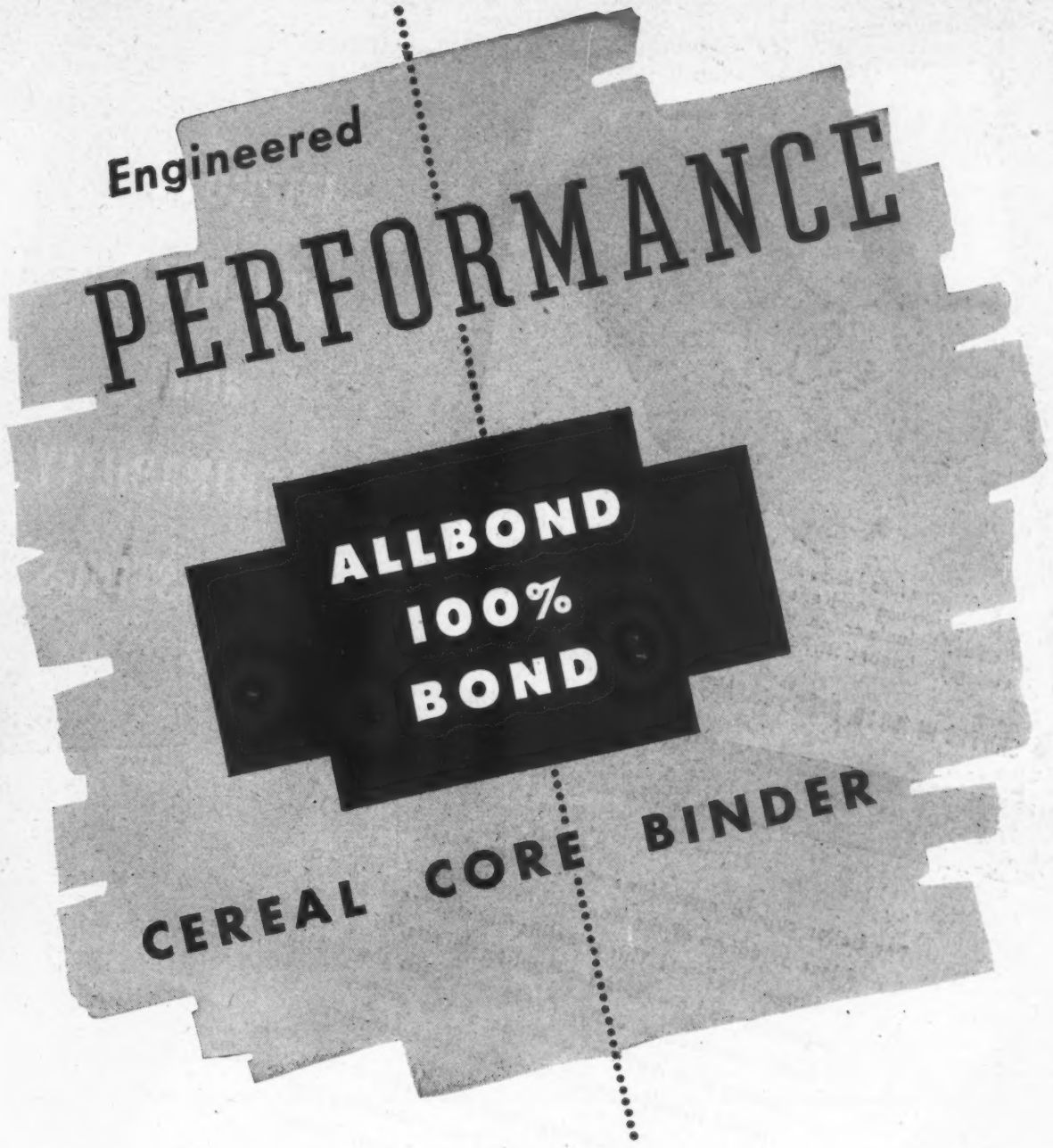

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NOVEMBER, 1945 VOL. VIII, NO. 4

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The American Foundrymen's Association is not responsible for statements or opinions advanced by authors of papers printed in its publications.

Published by the American Foundrymen's Association, Inc., 222 West Adams St., Chicago, Ill., for the purpose of presenting Association and Chapter activities. Published monthly.

Subscription price, to members, $4.00 per year; to non-members, $6.00 per year. Single copies, 50c. Entered as second class matter July 22, 1938, at the post office at Chicago, Illinois, under the Act of March 3, 1879.

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WHO ARE THE AUTHORS *In This Issue?*

The men whose names are shown on these two pages deserve the thanks of the industry for their contributions to the 1945 "Year-'Round Foundry Congress" . . . in many cases, completed in spite of cancellation of the Detroit convention.

M. W. Daugherty

Co-author (with L. W. Kempf) of paper in this issue on *"Density of Light Alloy Castings"* . . . A "Hoosier" by birth, a native of Indianapolis . . . Received chemical engineering degree from Purdue University, Lafayette, Ind., in 1923 . . . Affiliated with Aluminum Co. of America, Niagara Falls, N. Y., as chief chemist until 1931 . . . Now is research chemist at the Cleveland plant . . . Holds membership in American Chemical Society and ASM.

H. A. Schwartz

See, in this issue, *"The Influence of Radiation Within Molding Sand on the Freezing Rate of Metal"* . . . Born in Oldham County, Kentucky, 1880 . . . Obtained his technical education at Rose Polytechnic Institute, Terre Haute, Ind., receiving his Bachelor of Science degree in 1901 . . . Master of Science degree gained in 1903 and two years following (1905) the degree of Mechanical Engineer . . . Presented the honorary degree of Sc.D. by this institution recently . . . From 1902 to 1920, Mr. Schwartz was connected with National Malleable Castings Co., Indianapolis, as draftsman, chemist, metallurgist and assistant superintendent . . . In 1920 was made director of research for the entire corporation, now known as the National Malleable & Steel Castings Co., Cleveland . . . A world-wide authority on malleable iron, Dr. Schwartz is known to foundrymen everywhere for his many papers presented before meetings of technical societies, his articles in the trade press, and his book on *"American Malleable Cast Iron"* . . . For his many technical and scientific contributions to the foundry industry, he was awarded at the 34th Annual A.F.A. Convention, held in 1930, the John A. Penton Gold Medal of the Association . . . In 1939 he was the recipient of the E. J. Fox Gold Medal of the Institute of British Foundrymen . . . A member of A.F.A. Malleable Division, Executive Committee; Chairman, Committee on Specifications, Malleable Division; and A.F.A. representative on ASTM committees and subcommittees of malleable iron castings . . . Was the Association's 1945 Foundation Lecturer on *"Solidification of Metals"* . . . A member of ASM, AIME, SAE, Iron and Steel Institute (British) and A.F.A.

Louis W. Kempf

Co-author (with M. W. Daugherty) of current paper on *"Density of Light Alloy Castings"* . . . Born in Luther, Mich. . . . Earned his Bachelor of Science (1923) and Master of Science (1924) degrees at the University of Michigan, Ann Arbor, Mich. . . . Joined the research engineering staff of Aluminum Co. of America, Cleveland, in 1924 . . . In 1930, appointed Chief of Cleveland Research division . . . His papers have appeared in numerous metal trade publications . . . Has presented papers before many technical meetings of A.F.A., ASM, and AIME, usually on aluminum alloys . . . Technical societies in which he holds membership: A.F.A., AIME, ASTM, and Institute of Metals (British).

E. C. Moorhead

See: *"Pattern Redesign for Increased Production"* . . . Author was born in Berwick, Pa. . . . Began his foundry career at the age of 14 when he was taught the molding trade by his grandfather at the Jackson & Woodin Mfg. Co., Berwick . . . This concern was absorbed by American Car & Foundry Co. . . . The American Car & Foundry Co. afforded its employees the opportunity to take a mechanical engineering course in the foundry field and which Mr. Moorhead successfully completed . . . He then worked in each of the company's five foundries at the Berwick plant . . . The author was appointed superintendent of the jobbing foundry in 1906 . . . The year 1913 he was named manager, Richmond Radiator Co., Reading, Pa. . . . During World War I he became superintendent, A. P. Smith Foundry, East Orange, N. J., and during the last months of the war did work for Edison Co. . . . Moving to Stamford, Conn., in 1919 he was named superintendent, H. & H. Foundry Co. . . . The Kings County Iron Foundry, Brooklyn, assumed control of the Stamford plant and Mr. Moorhead was made manager of both plants . . . In 1929 he opened an office in New York City as a consulting foundry engineer . . . He returned to Connecticut in 1941 to join the staff of the Laconia Malleable Iron Works, Laconia . . . After 51 years in the foundry industry, the author retired in 1945 . . . He has written quite frequently for the trade press on various foundry subjects.

J. S. Vanick

Author of paper herein on *"War Time Developments in United States Cast Iron Foundry Practice"* . . . This is the official A.F.A. exchange paper presented before the French Foundry Technical Association at the first postwar French Foundry Congress in Paris, October 19-20, 1945 . . . A native of Cleveland, Ohio . . . Matriculated at Case School of Applied Science, Cleveland, and obtained a Bachelor of Science degree in metallurgical engineering in 1919 . . . Two years later (1921) received his Master of Science degree from George Washington University, Washington, D. C. . . . In 1916 became connected with the British Ministry of Munitions as engineer of tests, New York and Chicago . . . From 1917-19 held the same position as engineer of tests with the U. S. Army, Washington, D. C. . . . In 1919 was appointed

research metallurgist for the U. S. Army, Bureau of Standards, Washington, D. C. . . . Three years later (1922) accepted a position with the International Nickel Co., Bayonne, N. J. . . . At present is research metallurgist at that plant . . . Has written extensively for the trade press on cast iron and related subjects . . . Has addressed a majority of the thirty A.F.A. chapters and other technical societies and associations throughout the country . . . Talks have been on cast iron production, engineering properties, heat treatment, etc. . . . Has been, and still is, a member of many A.F.A. Gray Iron Division committees . . . A member of AIME, ASM, ASTM, Gray Iron Founders' Society, British Iron and Steel Institute and A.F.A.

J. J. Clark

See his article in this issue: *"Malleable Sand Control in a Large Mechanized Foundry"* . . . Born in Royal Oak, Mich., on the first day of August, 1909 . . . Received his Bachelor of Science degree from Michigan State College, Lansing, Mich., in electrical engineering, 1931 . . . Has been associated with Saginaw Malleable Iron Division, General Motors Corporation, since 1932 . . . Started as a chemist and in 1936 was made a draftsman . . . One year later was assigned to the metallurgical department and at present is assistant metallurgist . . . Member of ASM and A.F.A.

J. F. Cotton

Author of current paper *"Steel Castings Repair Methods"* . . . Mr. Cotton was born in Detroit, January 20, 1908 . . . Graduated from Michigan College of Mines, Houghton, Mich., in 1929 with a Bachelor of Science degree in metallurgical engineering . . . Began his industrial career with Carborundum Co., Niagara Falls, N. Y., as metallurgical engineer . . . Early in 1929 became affiliated with Bethlehem Steel Co., Bethlehem, Pa., and in a relatively short time was transferred and made metallographist at the Bethlehem Steel Co., Steelton, Pa. . . . In 1941 assumed his present position as metallurgical supervisor of the Steelton plant . . . Has spoken before many societies on magnetic particle inspection and repair of steel castings . . . A member of ASM.

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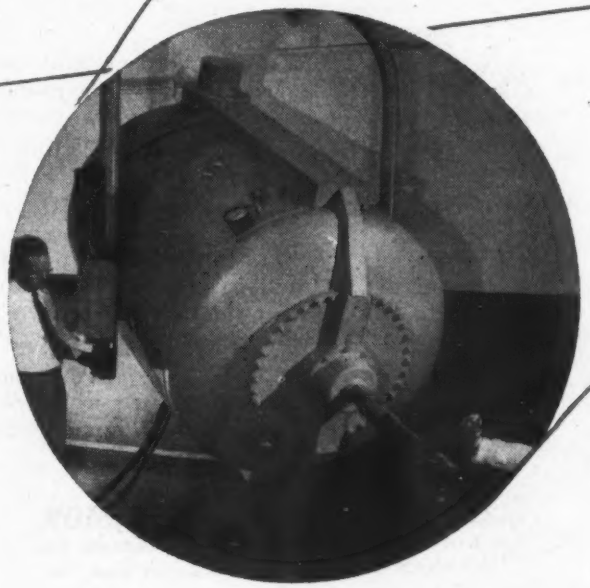

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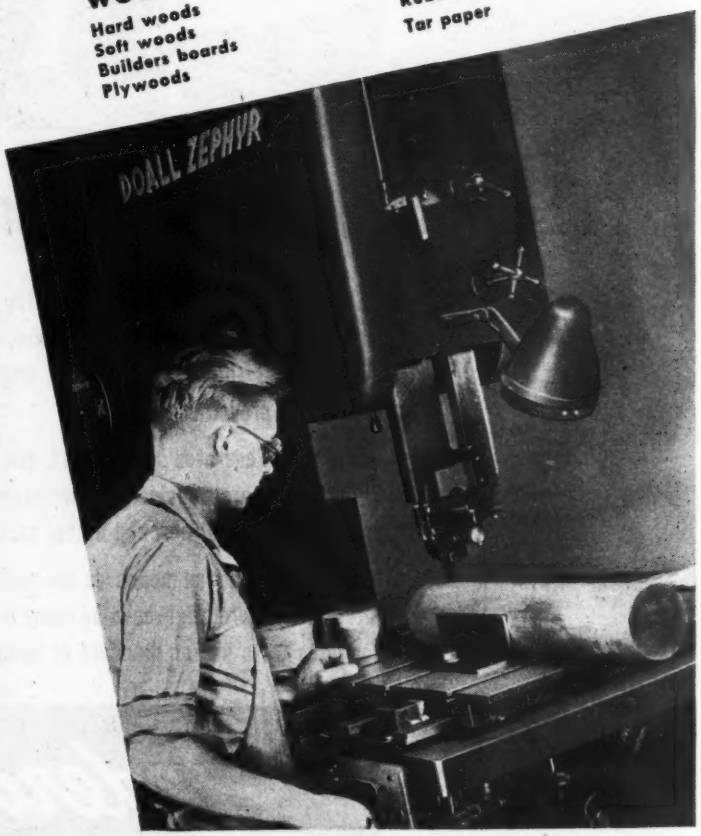

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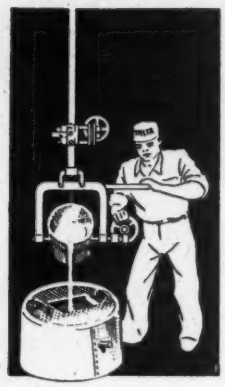

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This case history proves what many a foundryman has learned to his profit—radiography, by showing what is wrong, helps make better castings . . . replacing costly rejections with customer goodwill.

You'll save by using radiography

With industrial x-ray, you just won't send castings out that will give either you or your customers "rejection" trouble. You'll save time and money, too.

Radiography, besides being a great helper in correcting faulty casting technic, is a dependable guide—a guide that topflight designers use before making basic changes in design, materials, or processing.

Radiography has established itself as an essential industrial tool. Use it to improve your products and develop new markets. Call your local x-ray equipment dealer—he'll tell you how.

EASTMAN KODAK COMPANY
X-ray Division, Rochester 4, N. Y.

Radiography

ANALYZES . . . INSTRUCTS . . . CORRECTS . . . IMPROVES

Kodak

COOLER CUTTING

THESE new Electro High-Speed Grinding Wheels afford faster cutting without troublesome heat development whether the grind is for snagging or for fine finishing.

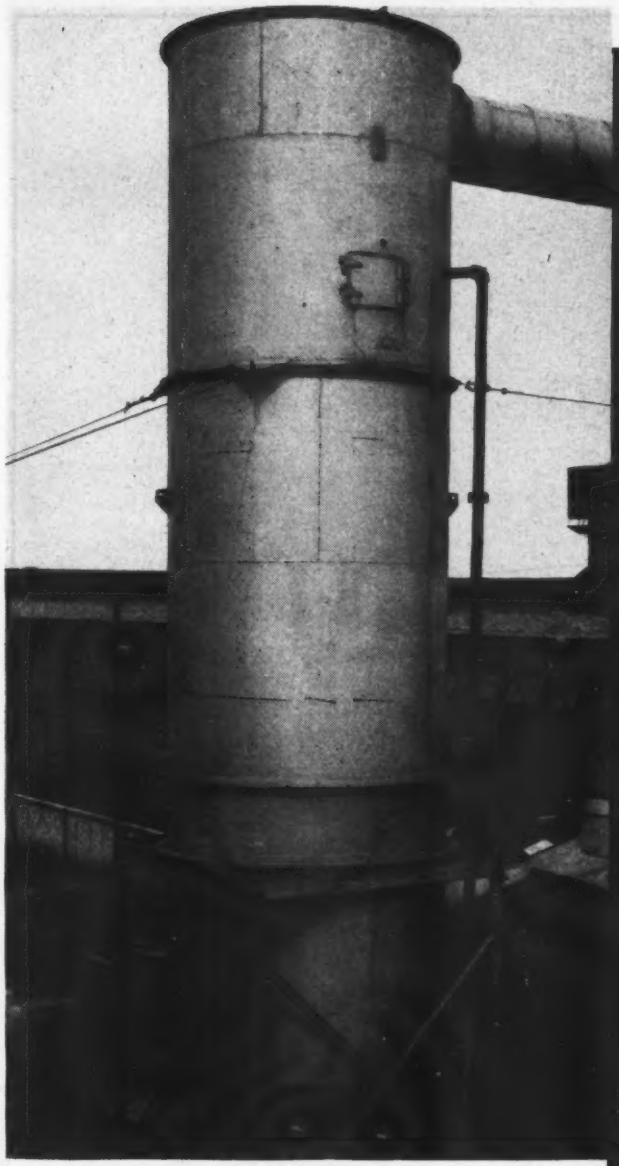
We believe that war demands made it possible for ELECTRO to show cooler cutting at higher speeds, and present high state of perfection will be the basis for further gains. All we ask is opportunity to prove the cooler cutting at higher speeds of our wheels.

Will you wire us?—or phone us at Buffalo, WAshington 5259?

K-310

Mfrs. of Crucibles • Refractories • Stoppers • Alloys • Grinding Wheels

SINCE 1919



WHAT WILL YOUR COSTS BE IN 1946?

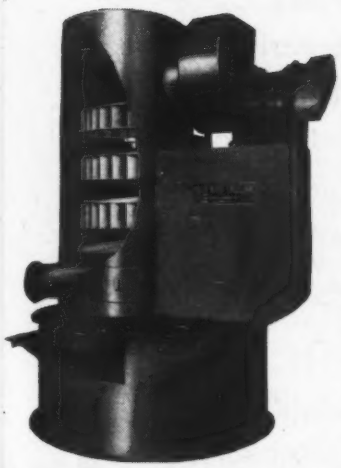
Prominent among your costs is labor—in terms of output per man-hour. Good working conditions, including clean, dust-free air in the working zones, were desirable in pre-war days . . . important in wartime . . . *imperative today*. Contaminated air sharply reduces what you get in return for the wage rates you pay. Only the most effective and economical dust collecting equipment is good enough now.

Schneible Multi-Wash Dust Collecting Systems do a continuous and thorough job of maintaining clean air in the working areas. Schneible equipment requires practically no attendance and a very minimum of maintenance. There are no filters, screens or bags to require periodical cleaning. There are no moving parts in the collector tower—nothing to break, burn, clog or rapidly wear. The collected material, as sludge, permits of much easier disposal than an accumulation of dust. The water used as a collecting medium is reclaimed in a Schneible dewatering tank and used over and over again.

Schneible dust control system affords the greatest ultimate economy, which is why foundries equipping for the competitive era have chosen Schneible in great preponderance.

Write for informative bulletins, and tell us about your dust and fume problems.

Claude B. Schneible Co.
2827 Twenty-fifth St.
Detroit 16, Mich.
Engineering Representatives in Principal Cities



One of two Schneible Multi-Wash Collectors used at a large steel foundry to ventilate all shakeouts, sand conditioning, cleaning, grinding, heat treating and other operations where dust and fumes are created. Schneible collectors are installed at six plants owned by this company.

For isolated operations and small plants, the Schneible Type "EC" unit provides a complete Multi-Wash dust and fume control system, including dewatering tank and circulating pump. These portable, self-contained units are made in capacities from 400 to 5,000 c.f.m.

SCHNEIBLE

LIQUID-VAPOR INTIMATE CONTACT EQUIPMENT for DUST COLLECTION ABSORPTION CONDENSATION AND TEMPERATURE REDUCTION

Silverstein and Pinsof
INCORPORATED

ANNOUNCE

the appointment of Lt. William A. Meissner, Jr. U.S.N.R. as Director of Sales. Mr. Meissner, Jr. was released from active duty in the Navy and took up his new role October 15th.

Lt. Meissner, Jr. has had a colorful career--in charge of sales at Farnan Brass Works, Cleveland...then called to Washington in early 1942 to be Chief of the Foundry Production Section, Copper Division of the War Production Board ...and, for the past two years, officer in charge of the Copper Section in the Bureau of Ships, Washington, D. C.

As Director of Sales, Mr. Meissner, Jr. will relieve Mr. Milton Silverstein, president of the company, who was in charge of sales heretofore.

SILVERSTEIN AND PINSOF, INC. . . . 1720 ELSTON AVENUE . . . CHICAGO 22, ILLINOIS

Exceptional HEAT UNIFORMITY

...with MAEHLER ovens...

. . . mean more uniformly baked cores

RECENT TESTS SHOW . . . temperature variations of only 5°

93.6%
OF MAEHLER'S PRODUCTION
IS DEVOTED TO REPEAT ORDERS!

. . . . . There is no better proof of the superiority of Maehler ovens and furnaces.

MAEHLER'S leadership in developing the recirculating air heat system for industrial ovens has resulted in a line of equipment that gives heat uniformity that is virtually *perfect!* Recent tests show that a Maehler oven operating at 500°F fully loaded maintained a heat uniformity within 5°, through high volume and rapid air heat circulation and highest grade instruments. This kind of temperature control means uniform baking . . . no under-baked nor over-baked cores.

Maehler core and mold ovens are available in a complete range of oil fired, gas fired and electrically heated units, incorporating the Maehler recirculating principle for high uniformity and output, at low cost.

Let us quote you on your requirements.

THE PAUL MAEHLER COMPANY
2218 W. Lake Street • Chicago 22, Ill.

A Few Users of
MAEHLER EQUIPMENT

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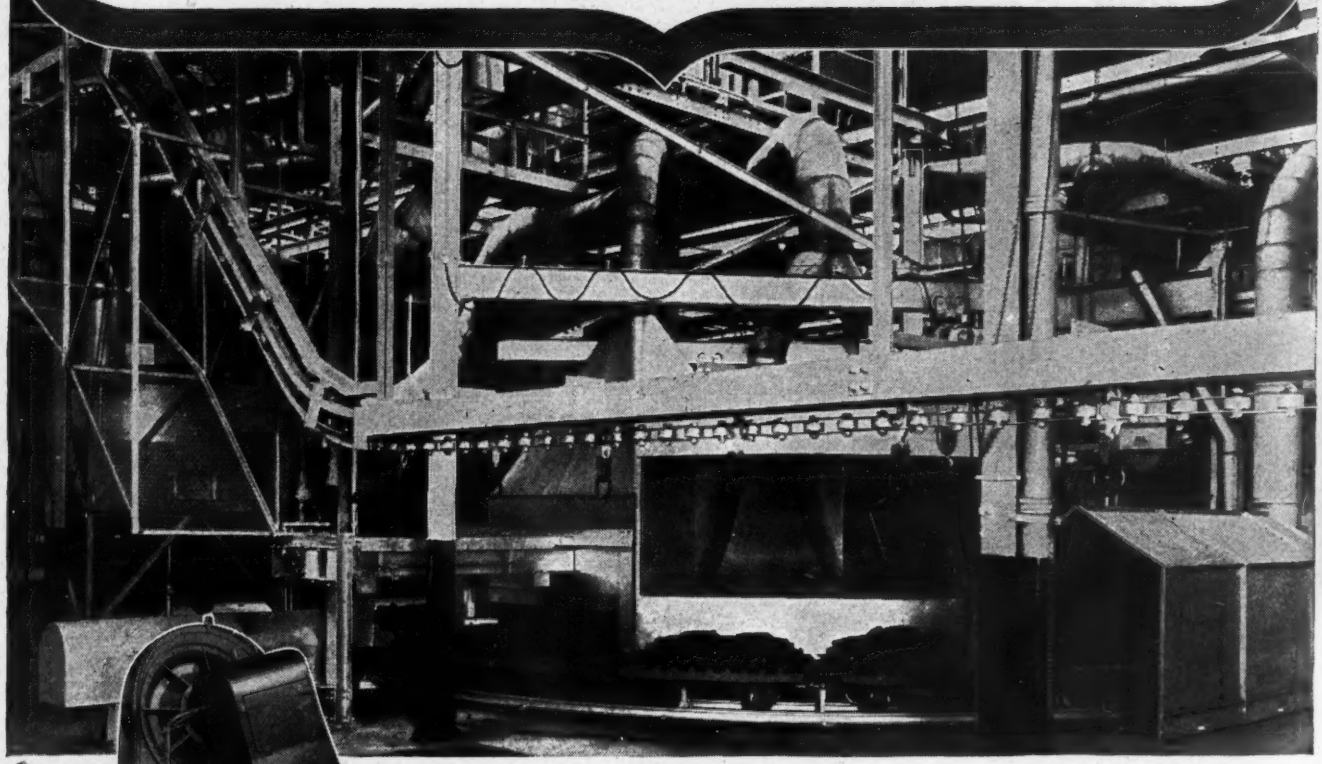
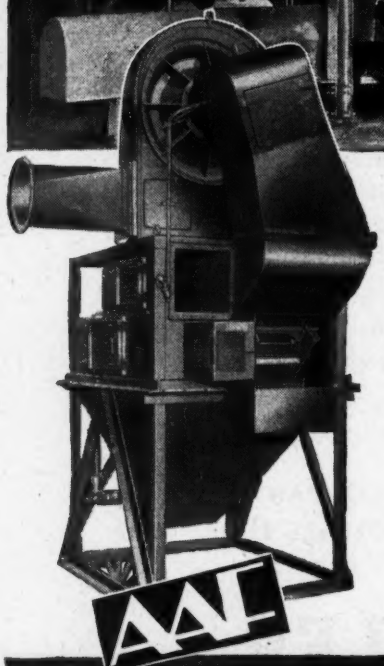
Industrial Ovens and Furnaces for Core Baking, Mold Drying, Heat Treating, Enameling, etc.

ROTO-CLONE*

for automotive foundry

DUST CONTROL





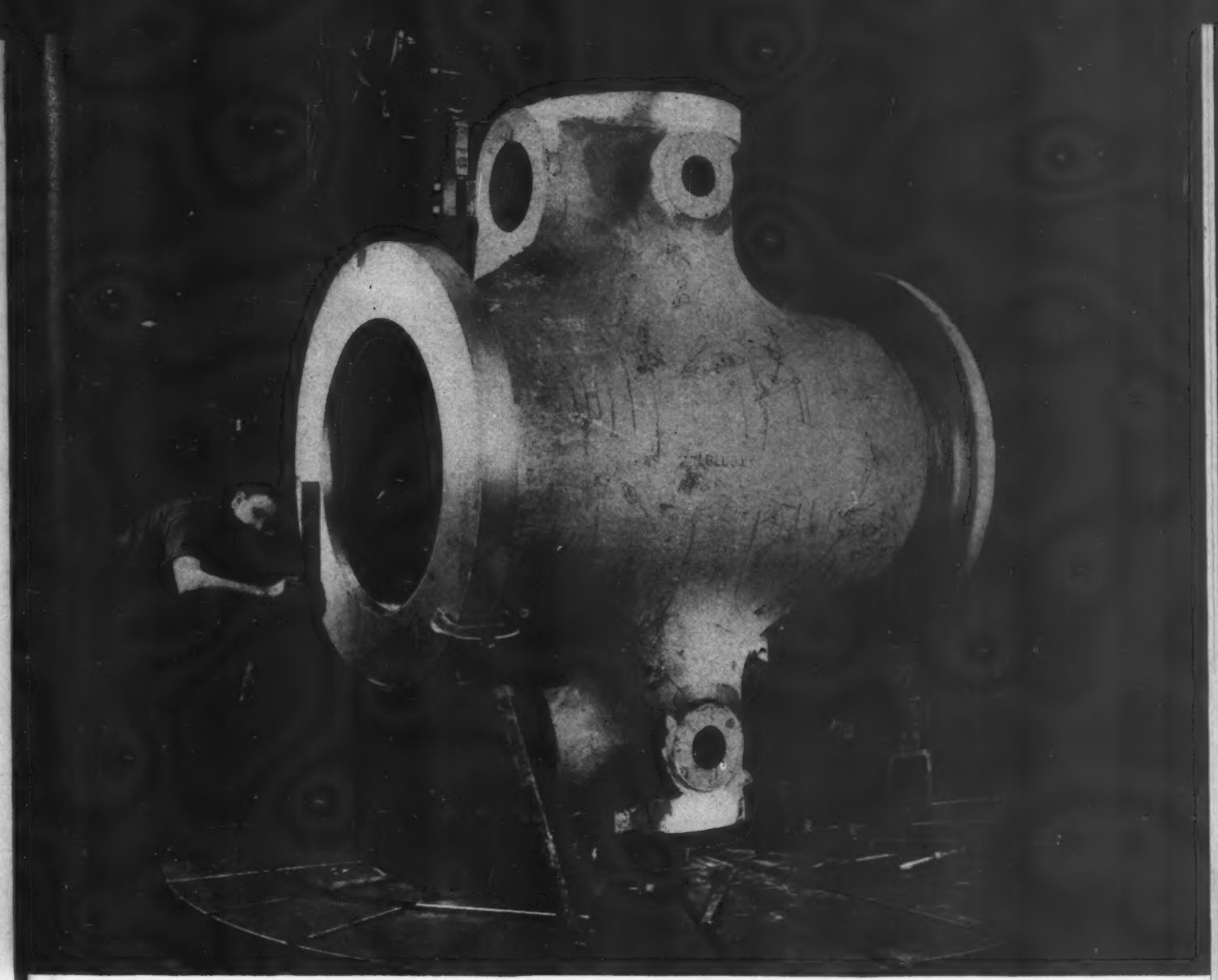
In heavy duty shakeout service Roto-Clone has proved its value through years of successful performance. The Type W Roto-Clone, which can be seen in the background at the left of the picture above, exhausts the cope and drag shakeout and the casting removal station. This Roto-Clone dust control installation is typical of many such systems serving leading foundries throughout the country. For information on the Type W Roto-Clone (wet type) for foundry service, ask for Bulletin No. 274 A.

*Registered Trade-Mark for a Dynamic Precipitator or Hydrostatic Baffle-Type Wet Collector.

AMERICAN AIR FILTER COMPANY, INC.
104 Central Avenue, Louisville 8, Ky.
In Canada: Darling Bros., Ltd., Montreal, P. Q.

MANUFACTURER'S ASSOCIATION, INC. FOUNDRY EQUIPMENT

TYPE W ROTO-CLONE



THE STRENGTH FOR GIANT TASKS
—IS FOUND IN VANADIUM STEELS

Strength—without excess weight—the greater strength that permits weight and material savings in modern designs, the greater strength that insures an extra margin of safety and longer service life... you'll find it in vanadium steels.

Like the giant casting shown above—a water nozzle weighing approximately 17 tons—which easily met not only hydrostatic pressure tests of 3000 lbs. per square inch but thorough magnaflux inspection as well.

The Carbon-Vanadium Steel used in this casting developed the following physical properties, typical of the advantages these cast steels offer:

Elastic Limit p.s.i.	61,650	60,800
Tensile Strength p.s.i.	87,150	83,900
Elongation %	26.5	27.7
Reduction of Area %	49.2	50.7

The background of experience of our metallurgical engineers is at your service in any application where *"alloy steels can do the job better!"*

MAKERS OF VANCORAM FERRO ALLOYS AND METALS

All government restrictions on Vanadium shipments have been lifted. Adequate stocks on hand assure immediate shipment and quick delivery of Ferro Vanadium and other Vanadium products.

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HOW TO MAKE IMPLEMENT AND TRACTOR PARTS

Last Longer...Work Better

TYPICAL ANALYSES OF ALLOY CAST IRON IMPLEMENT AND TRACTOR PARTS

Applications	Total Carbon	Silicon	Nickel	Chromium	Molybdenum	Brinell Hardness	Tensile Strength (lbs./sq. in.)	Desirable Characteristics
Pulleys and Frames	3.40-3.60	2.00-2.50	.25- .50 .50- .80	.....	.....	160-180 160-180	35,000 min.	Improved Machinability Resistance to Impact Resistance to Wear Improved Machinability
Clutch Plunger Rods	3.20-3.40	1.80-2.10	.50-1.00 .60-1.00	.25- .40	.....	160-200	35,000 min.	Resistance to Wear Improved Machinability
Clutch Plates	3.00-3.25	1.60-2.00	.50- .80 .60- .90	.20- .35		175-225	35 to 50,000 min.	Resistance to Wear Improved Machinability Resistance to Wear Heat Treat Hardenability
Brake Drums	3.00-3.25	1.60-2.00	1.00-1.50 1.25-1.75	.40- .60 .35- .60	.25- .45			Improved Machinability
Gears and Sprockets	2.75-3.20	1.40-1.80	.40- .65 .75-1.25 1.00-1.50 1.50-2.00 2.00-2.50	.15- .30 .30- .60 .50- .80	....	175-275	35 to 60,000 min.	Improved Machinability Resistance to Growth
Cylinder Heads	3.00-3.25	1.40-1.80	.30- .60 .50- .80 .60-1.10	.15- .30 .25- .50 .15- .30	....	170-200 170-200	35 to 40,000 min. 35 to 40,000 min.	Improved Machinability Resistance to Growth Resistance to Growth
Motor Blocks	3.00-3.25	1.40-1.80	.30- .60 .45- .80	.15- .30 .25- .40	.....	160-190	35 to 40,000 min.	Resistance to Wear Heat Treat Hardenability
Exhaust Manifolds	3.00-3.25	1.40-1.80	.30- .60 .75-1.25	.15- .30	.....	190-260 350-500	As Cast 40 to 60,000 min. As Heat Treated 75,000 min.	Improved Machinability Resistance to Growth
Cylinder Sleeves and Liners	2.90-3.25	1.30-1.70	.50-1.00 1.25-1.75 1.50-2.00	.30- .60 ..... .50- .80	.30- .60	As Cast) 190-300)	40 to 50,000 min.	Resistance to Wear Heat Treat Hardenability Improved Machinability Resistance to Growth Resistance to Impact
Valve Inserts	2.90-3.25	1.40-1.80	.50- .80 .50- .80	.40- .60 .30- .50	.30- .50			Resistance to Wear Heat Treat Hardenability Improved Machinability Resistance to Impact
Crankshafts	2.60-2.90	1.70-2.00	1.00-1.50 1.50-2.00 1.75-2.25	.....	.70-1.00 .30- .60 .40- .80	250-290 As Cast 300-420 As Heat Treated	65,000 min. 80,000 min.	Resistance to Wear Resistance to Impact
Seed Grinding Burrs	3.50-3.75	.50- .75	3.25-3.75	1.90-2.20	.....	*600-750		Resistance to Wear Resistance to Impact
Plow Points	3.25-3.50	.80-1.10	4.25-4.75	1.50-2.00	.....	*550-750		

*Chill cast or sand cast white.

LET THIS TABLE BE YOUR GUIDE TO 5 IMPORTANT BENEFITS OF Nickel Alloy CAST IRON

Use this handy table.

It's a useful guide to help you pick the right alloy cast iron for each point of stress or wear in your equipment.

It's surprising how much improvement can be made with the right metal in the right place.

Especially suited to agricultural uses, Nickel cast irons afford resistance to wear, to impact, and to growth at elevated temperatures.

In addition, these cast irons possess heat treat hardenability, grain refinement, and improved machinability.

Nickel imparts strength, hardness, toughness and resistance to wear and to corrosion.

Consultation on the use of alloys containing Nickel in your product or equipment is invited.

THE INTERNATIONAL NICKEL COMPANY, INC., 67 WALL STREET NEW YORK 5, N. Y.

SHOT *blasting*
GRIT *blasting*
SAND *blasting*

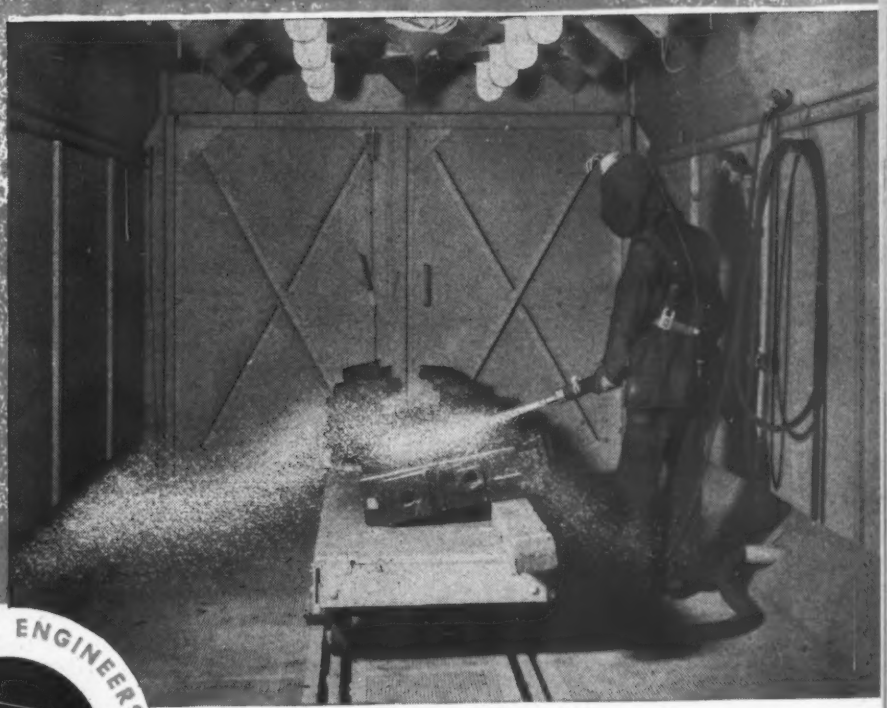
With PAR-BLAST EQUIPMENT CUTS CLEANING COSTS!

Shot, grit or sand blasting, coupled with Par-Blast equipment, reaches a new high in efficiency and greater speed. Over a quarter century of creative engineering experience, plus modern manufacturing facilities enable us to analize and recommend the best equipment for your plant. *Our engineers will be glad to discuss your problems without obligation.*

PAR-BLAST ROOMS . . . are furnished in a number of sizes and designs to fit individual requirements. Included are the *Turntable, Car and Monorail types.* Detailed features . . . effective blast tanks . . . efficient abrasive reclaiming units . . . the latest down-draft ventilation and proper illumination. Walls are heavy steel plate, properly reinforced and braced for strength and rigidity. Doors are self-closing and self-sealing.

- **AUXILIARY EQUIPMENT . . . Operators' helmets designed to eliminate fatigue. Passes all safety requirements. Includes *all* accesssories.**
- **BLAST ROOM CARS . . . Par-Blast industrial cars are unique in that the height is kept to a minimum . . . work is cleaned directly on car. All sizes with open top for hauling and cleaning exceptionally large pieces.**

Send for new Bulletin R-42



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Parsons ENGINEERING CORP.

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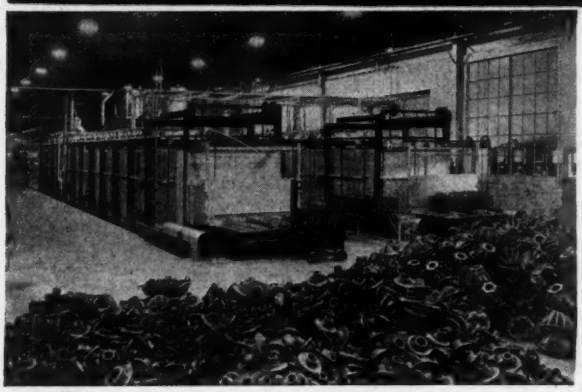
EF FURNACES

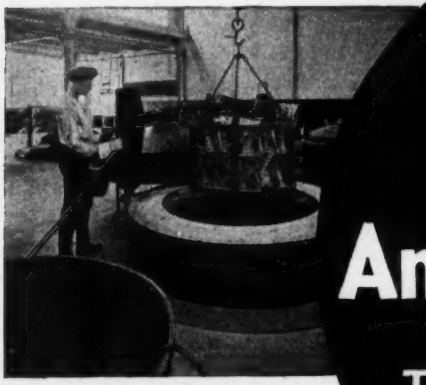
For Every Industrial Heat Treating Process



Scale Free Annealing Castings
40,000 lbs. of castings per day are annealed, scale-free, in the above EF continuous special atmosphere short cycle annealing installation.

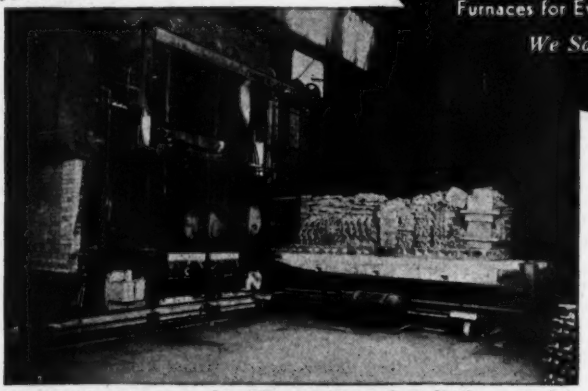
Heat Treating Large Castings
Railroad castings, heavy tank castings and other large parts and products are annealed or heated and quenched in EF furnaces similar to above.

A Few
Electric and Fuel Fired
Continuous and Batch Type
FURNACES
FOR
Annealing Castings
Designed and Built by
The Electric Furnace Co.
Salem, Ohio
Furnaces for Every Industrial Heating Process
We Solicit Your Inquiries



Aluminum, Magnesium
and other non-ferrous and ferrous castings are uniformly heated in EF pits and other continuous and batch type units.

Large Alloy Castings
Charging end of a large EF oil-fired roller hearth furnace annealing large castings—continuously.



Steel Castings. An EF car type installation consisting of two heating chambers, a cooling chamber, car puller and cross transfer car, for annealing steel castings.

Car Bottom Furnaces. EF car type furnaces are built in any size, with single chambers, multiple chambers with cross transfer car, or with quenching means as required.

Additional data on these or other types of EF Production Furnaces sent on request.

The Electric Furnace Co., Salem, Ohio

Gas Fired, Oil Fired and Electric Furnaces---For Any Process, Product or Production

Quality in any product is the result of care in planning, preparation, raw materials selection and production control . . . it is not achieved by accident.

Years of effort and ripe experience, large investments in the most modern control equipment, and the skills of many experts, are all combined to produce today's high quality Smelters' Aluminum Alloys.

For freedom from oxide inclusion; for controlled grain structure; for uniformity; for complete satisfaction in any casting application; specify our laboratory-controlled Aluminum Alloy Ingot. Its quality and dependability have been planned.

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111 West Washington Street, Chicago 2, Illinois

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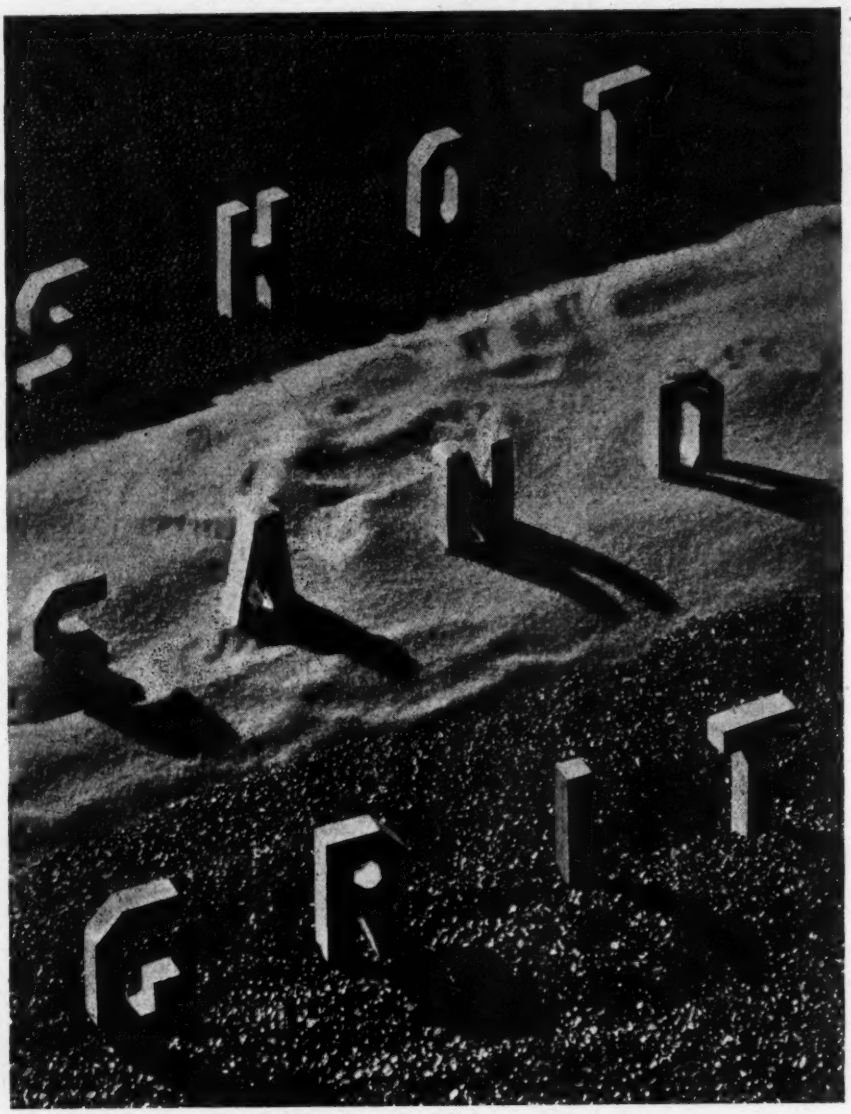

FOR PEENING, cleaning and blasting, finish is improved—costs reduced—by the use of Great Lakes materials and methods.

We have a complete line of mineral and metallic abrasives, carefully processed and graded. Our alloyed steel shot and grit are manufactured to close tolerances to SAE specifications, free from hollows and useless shapes for effective impact.

Our service includes recommendation of the correct abrasive and suggestions as to proper adjustment of your equipment to the abrasive and to the character of your work. Let us help you reduce your abrasive costs!

SAND BLASTING ENGINEERING SERVICE . . . inaugurated by Great Lakes 20 years ago has effected tremendous savings in power and abrasive in hundreds of plants.

We invite you to avail yourselves of this service by having your blasting operations checked and necessary adjustments made by us at regular intervals.

Great Lakes Foundry Sand Co.

BUY GREAT LAKES!

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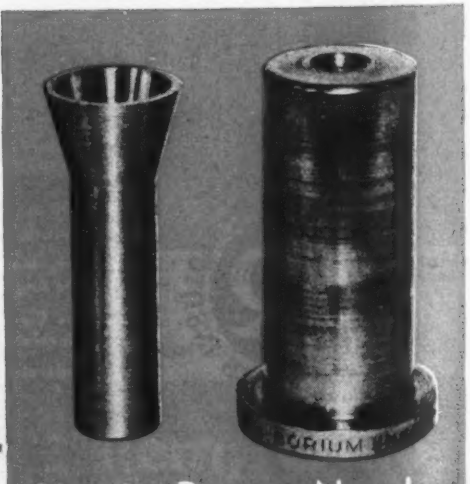
Miners—Processors—Foundry, Metallurgical and Sand Blast Service



Stoody Borium Nozzles

FOR ECONOMY'S SAKE

The Foundry Industry Sells Something Besides Castings

TO maintain the respect the foundry industry has so rightfully earned by its recent contribution to the war effort, it is necessary for us to secure the increased services of brains and manpower. In order to procure such commodities, we must sell our industry to our future employees. As in the case of castings we have competition, and unless we embark upon a campaign of salesmanship to obtain our share of the available workers, we will eventually be faced with a shortage of workers more serious than we are experiencing at the present time.

Any successful sales campaign is primarily based on a value to be offered and proper presentation of it. In this case, the value we offer is the opportunity to earn a good living and a reasonable chance of earned advancement. Next we must make our merchandise attractive. Our foundries must be clean, well lighted and ventilated and we must provide for the reasonable comforts of our workers. Modern equipment and labor saving devices should be installed and our workers trained and encouraged to use them to the best advantage. When these provisions have been made we are ready to contact our prospects.

It is doubtful if a greater field is open to the undergraduates of our colleges, universities and engineering schools. Of course, we need molders, coremakers, patternmakers, as well as less skilled help, but the key to the situation lies in the hands of the coming generation of young engineers and technically trained men. These are the ones who will have the qualifications for improving our present methods and equipment, and make our Industry a more attractive one in which to work, as well as bring about improvements in our products.

A surprising number of undergraduate engineers approach the end of their college training without any definite plan as to which and what kind of a career they will undertake. Here is our opportunity and we should begin selling ourselves to them before they leave.

It is doubtful if any other industry has so much to offer with which to excite the imagination of the young engineer as does the foundry. Perhaps more of the arts and sciences are involved in the making of metal castings than any other product. However, these young men cannot be aware of this, or the opportunities open to them, unless we go before them with the facts. Therefore, we should avail ourselves of this privilege and appear before them in the colleges and schools with carefully planned programs. Invite them to visit our plants, attend our chapter meetings and cultivate them in every possible way. Privately or group sponsored projects in which they may participate can have much to do with creating interest and are of immeasurable profits to all concerned.

Several foundries have done and are still sponsoring such activities and the results are most encouraging, but this should be practiced more frequently and by a greater number of chapters or by individual concerns in cooperation with their local chapters. Hardly any other project could do more good for both the Industry and our Association.

Not all of these young men will become our future employees, but those who do not will probably be our future customers and we will have done a good job of selling if we have made them all "Casting Conscious."

F. M. WITTLINGER, *National Director,*
American Foundrymen's Association

PATTERN REDESIGN

for Increased Production

By Ernest C. Moorhead,
Consulting Foundry Engineer,
Laconia, N. H.

• Use of sample or temporary pattern equipment for production castings often prevents maximum production. Redesign of pattern equipment for efficient operation is sometimes difficult, but time and thought given to adapting the pattern for increased production may mean the difference between profit and loss in the jobbing foundry.

IN many foundries, especially those of the jobbing type, certain castings are made from an original pattern for many months or possibly years. In many such instances, production could be increased from 100 to 500 per cent by some minor changes to the pattern design and equipment without necessarily changing the casting proper.

This lack of maximum production from a given pattern is the fault of no particular individual, as most patterns can be made in several different ways from the same drawing. Besides, designers of machines and parts are not always sure that the original design is exactly what they will require, and changes may be necessary after the sample castings are received from the foundry.

Due to this line of thought, many patterns are made at the least possible expense and are sent to the foundry for samples. Many times the samples are satisfactory and immediately more castings are ordered. As time goes on, the foundry regularly receives orders to be made from the so-called temporary pattern. Orders of this kind generally are filled in a piecemeal fashion, and many times at a loss to the foundry. Thus, a minimum production is continued indefinitely.

To adapt such pattern equipment to cope with this increase in production, the foundryman must study and really ponder over the patterns under consideration. This is not always easy, and sometimes takes weeks of thought to reach a definite conclusion. If the foundryman is successful in his efforts, he finds himself greatly rewarded, and the satisfaction that is his is worth more to him than money.

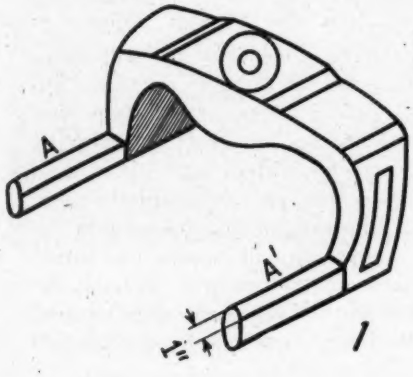
In any line of work, where there is a job to be done which can be made only by certain persons, because of the skill required, it can be accepted as axiomatic that the job is not being made in the easiest or the best way. Personally, the author does not like to think of a tough job in the foundry that cannot be made into an easy one.

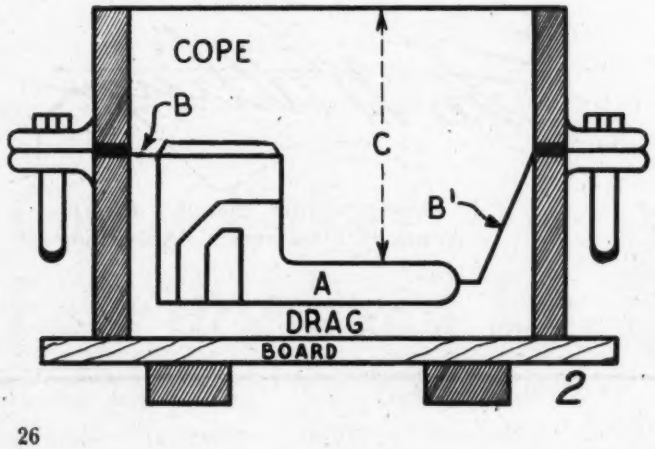
In the following, the author points out how small pattern changes can greatly increase the foundry production and save a lot of supervision and attention on jobs in the "breaking even bracket."

Figure 1 is a sketch of a malleable casting that formerly was made on a side floor in a 20x26-in. wooden flask with a 6-in. cope and a 7-in. drag. The casting, however, is somewhat more complicated than is shown, but the only parts of the pattern that need be considered are the arms (A and A¹, Fig. 1), which make necessary a deep parting line (B-B¹, Fig. 2) at the joint of the flask.

Note the depth of cope in Fig. 2, indicated by line (C). Due to this heavy pocket of sand which extends the full length of the cope, it was necessary to set gaggers through this pocket to insure a good lift and to keep the cope from falling out while the mold was being closed.

As originally made, the drag was rammed on a "clay match" 5 in.





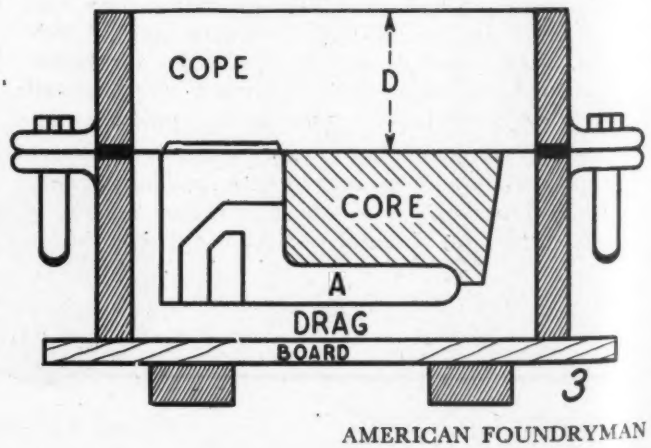


Fig. 1—Sketch of casting on which low production was encountered because of molding method used. Fig. 2—First method of molding. Fig. 3—Use of cores to simplify molding, reduce losses and increase production.

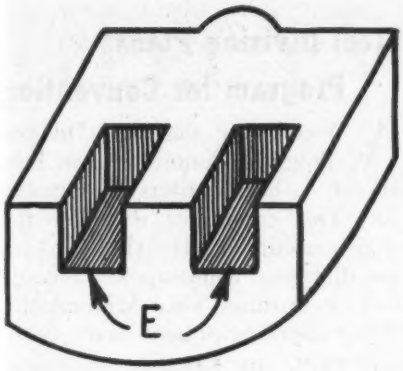


Fig. 4—When molded in green sand, without cores, the pockets lifted against one another causing high mold repair time and low production.

deep, and the drag and the "match" were about as much as a man could handle. With this equipment, a jobbing molder made ten castings per day, with a heavy loss.

The arms A-A¹ are only one in. wide, but the whole cope surface had to be rammed just to get the impression of these arms, or a surface of 2-in. width, far beneath the body of the casting, as shown in Fig. 1.

To simplify the molding operation, reduce the cope lift and eliminate the use of gaggers in the cope, a block core 2 in. wide and 7 in. long and 5 in. high with plenty of taper, to avoid dragging sand when the cores were being set, was made. Two of these cores were used in each mold, one core over each arm. It might be well to add that, in the manner the "clay match" had to be made, the depth of the lift in cope was about doubled. In the original method, the shrink and pressure heads of the gates were also in the pocket between the arms, which complicated matters.

Figure 3 shows the cores in place. Core prints, of course, were added to the pattern, which raised the parting line level with the joint of the flask, as shown. By adding these core prints, the cope became practically a "flat back" and permitted all the green sand between the core prints to remain in the "drag" instead of being lifted in cope, as shown in Fig. 2.

Because this change made the parting line so simple and easy, a new pattern was made on a "cope and drag" molding board, which did away with the old "clay match" or follow board. The patterns then were put on a "rollover machine" and the machine molders now make 60 to 70 castings per day with a very small loss. The castings are of a better grade and more accurate.

In cases like the foregoing, some foundrymen buy metal flasks with joints which follow the irregular parting line of the pattern. At times, this is a very good way to make irregular parting line work, especially if that parting is extremely irregular. However, metal flasks are expensive and a foundry often finds itself with a lot of money tied up in metal flasks that can be used only on one job. Since the new pattern design provided a very plain cope line, it was found more advisable to use a 16x21-in. snap flask with a 6-in. cope and a 7½-in. drag.

In this case, it was found that the snap flask was better than the metal flask. With a metal flask, cut to the contour of the pattern, the cope would have been very unbalanced, which would have been awkward to handle and would slow down production.

In Fig. 4, note the pockets, marked E, in a simple pattern. Aside from these pockets, which are 2½-in. deep, 2½-in. long, and 1⅝-in. wide, there would be nothing to slow down production. However, these pockets have very little draft and, where two or more pockets of green sand must be lifted in the cope, one usually lifts against the other.

The molder, who originally made this job in a 13x16-in. snap flask, was one of the best. However, he had to set "soldiers" or 20-penny, clay-washed nails into these pockets to bring the pockets up in the cope. Many times, parts of the green sand would pinch off and, because a snap flask was used, it was necessary to place a board behind the cope to lay it flat on the bench so that the broken parts could be mended. Even so, a patched mold resulted.

As originally molded, a good man would make 30 to 38 castings per day of the type shown in Fig. 4, depending on his luck in lifting the cope. Whenever "soldiers," clay-washed nails, etc., have to be used by a molder in making a job, it involves valuable time and the work done is not absolutely safe or foolproof.

To increase production and eliminate mold repair time, an impression was made of the pockets (E) in plaster of paris, and a core box was built around this plaster impression. Core prints were added to the pattern and the job turned over to an apprentice boy. Working piece rate on a squeeze machine, he produces 100 to 125 castings per day. With this small change, any boy in the shop can make the work, as all of the tricky parts of the operation have been removed.

It does not pay to use a pattern which leaves its own green sand cores if these cavities cause the least possible signs of sticking or washing ahead of the iron when the mold is poured. In the long run, cores are

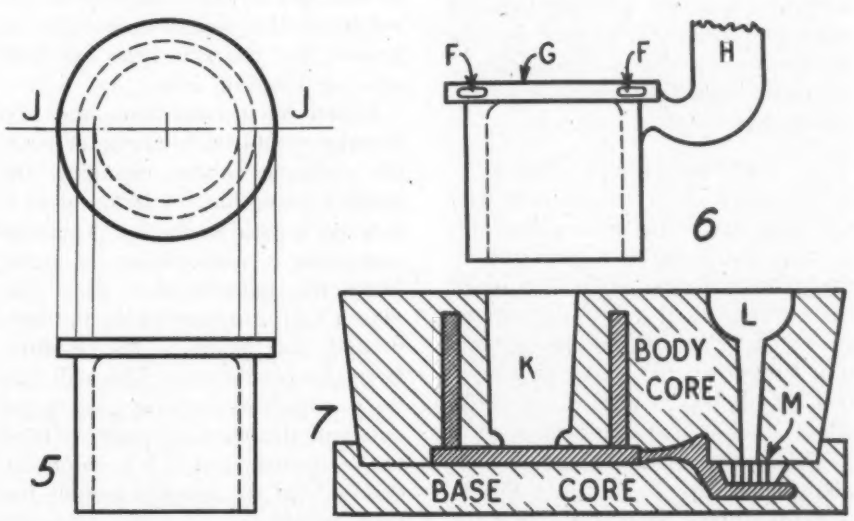


Fig. 5—Sketch of 5 in. dud shell butt casting. Fig. 6—Points at which defects developed in original molding method. Fig. 7—Final method adopted, using two cores instead of the green sand used in the original method.

cheaper than having a molder playing with some ticklish job simply to avoid making a core.

Figure 5 shows a sketch of a 5-in. dud shell butt to be used for practice purposes. When the foundry quoted on this job, it was understood that almost any kind of a casting would do. However, the drawing showed that the casting was to be machined all over.

Naturally, the foundry started to make these castings in the usual manner, using only a plain cope, as shown in Fig. 6. The samples were broken up and it was found that an internal shrinkage took place at points marked (F), Fig. 6.

Shrinkage Overcome

To overcome this shrink, a large feeder was set up as shown at (H), Fig. 6, which served its purpose, but grinding off this feeder cost more than to make the casting. However, at this stage the work was put into production.

The machine shop, which was in another city, did not start to machine the castings for some weeks, and the foundry had several thousand made. When the machining started finally, it was found that all of the castings were scrap, inasmuch as it was also found that the castings had small dirt and pin holes on the top surface shown at (G), Fig. 6. Thus, the foundry lost 100 per cent of several weeks' work on what had seemed to be the simplest kind of a job.

Since the castings now required had to be absolutely perfect and were required to take a high polished finish, it was assumed that the castings could not be cast by the plain molding system, as originally planned, with any degree of safety on the part of the foundry.

Castings Made in Core

Therefore, it was reasoned that the only way to make these castings in sufficient quantity was to turn to the pattern upside down. To make the castings in this position was of course impractical, so one pattern was screwed in the center of a core box, as shown in Fig. 7, and the whole casting was made in a core.

This core consisted of a base core and a body core, as shown in Fig. 7. A heavy shrink head was placed in the inside center of the pattern, which resulted in a big saving to the foundry as no grinding was necessary. The head, after being broken off, left only about ¼-in. still intact on the casting, and this was machined off in the machine shop when the inside of the shell butt was machined.

Core Location

The body core and the base core were made to locate the two core parts so that the pouring gate and the skim core would member properly when the two cores were put together. Provision was made in the base core to insert a skim core (M) and a lead gate, the skim core being set in the base core, as shown in Fig. 7, which was connected with the pouring gate (L). The base core was placed on the molding floor and the body core placed on top of it and weighted down for pouring.

The core boy received around 7 cents per pair of these cores, and with the sand and oil added, this method was less expensive than making the castings in green sand, if it had been possible to make them in the same position as made in the core or as made originally. Two hundred of these shell butt castings were cast daily for many weeks, which equalled the production reached when the job was started in green sand. All of the molders in the shop took turns pouring these shells at the end of the heat and were paid for the pouring.

Pattern Changes

Malleable foundries often receive patterns that are away out of proportion. The castings crack and shrink, and serious trouble often develops if the foundryman tries to ignore the characteristics of high combined carbon iron.

Under such conditions, the first impulse would be to phone or write the customer about changing the pattern somewhat. A better plan is to make a mold in the usual manner and pour it with plaster of paris. Have the patternmaker dress this plaster cast up neatly along the lines desired and make a few castings from this plaster cast. This will give the customer a working part to try out, and the working patterns need not be disturbed until it is absolutely certain that the foundry trouble has been eliminated and the customer is satisfied with the castings from the new design.

Steel Division Plans Program for Convention

A meeting of the Steel Division Program Committee was held at A.F.A. headquarters on October 26. This committee is under the chairmanship of H. H. Blosjo, metallurgist, Minneapolis Electric Steel Castings Co., Minneapolis. Other members present were: G. A. Lillieqvist, metallurgist, American Steel Foundries, East Chicago, Ind.; C. H. Lorig, Steel Division Chairman, Battelle Memorial Institute, Columbus, Ohio; and G. Vennerholm, metallurgist, Ford Motor Co., Detroit. As guests were members of the Executive Committee, Steel Division, these being A. W. Gregg, Whiting Corporation, Harvey, Ill.; and E. R. Young, Climax Molybdenum Co., Chicago.

The committee is planning three sessions for the 50th Anniversary convention. Nine papers and three committee reports are proposed. The subjects and authors of these will be announced later. In addition, the division will have a round table luncheon meeting, or informal discussion of steel foundry problems. The Chairman of the Round Table Committee is Thomas D. West, vice president, West Steel Castings Co., Cleveland.

Clark Prepares Fluidity Paper for IBF Exchange

KENNETH L. CLARK, metallurgist, Naval Research Laboratory, Washington, D. C., and Chairman, A.F.A. Fluidity Testing Committee, has accepted the invitation of the Association to prepare for presentation before the 1946 IBF meeting, the annual exchange paper from the A.F.A. Mr. Clark's subject will cover recent developments in fluidity testing and control.

This exchange paper arrangement was initiated in 1921 and has been continuous since that date. It is expected that there will be a similar exchange paper from the IBF to be presented before the A.F.A. 50th Anniversary Congress in Cleveland the week of May 6-10, 1946. With the close of the war, it is anticipated that exchange papers will be received from other overseas foundry technical associations.

STEEL CASTINGS

Repair Methods

By J. F. Cotton, Metallurgical Supervisor,
Bethlehem Steel Co., Steelton, Pa.

● Factors of casting service—character of the defect, as determined by the various test methods available—metal composition—must be considered in selecting a method of defect removal. After suitable examination to assure complete removal of the defect, it must be decided whether repair is necessary or desirable, and if so, the method to be employed.

AN understanding of the definition of the term "defect" should be a fundamental prerequisite required of all those who shall attempt to condition castings. A defect may be defined as the lack or absence of something essential or, in the foundry, as a discontinuity of metal that may have a harmful influence on the service of the casting. This discontinuity of metal may be due to cavities caused by gas or shrinkage; to included metallics such as chills and chaplets; to non-metallics such as sand and inclusions; to hot tears and cracks; or to combinations of these defects.

It follows that these discontinuities may not be defects unless their presence can be said to have a harmful influence on the service of the casting. The determination as to whether or not a certain type of discontinuity is a defect does not fall within the scope of this paper.

Determination Factors

It should be mentioned, however, that many factors must be taken into account in this determination. Among these factors are the intended service of the casting and the direction and magnitude of the discontinuities in relation to the stresses involved during the service of the casting.

Having determined that a certain discontinuity is a defect, it is then presumed that its location in respect to the depth below the surface and its size have been determined or estimated by visual inspection, cold acid etching, magnetic particle inspection, radiography, drilling, or by other test methods. With this information available and knowing the analysis of the casting, it becomes possible to consider the means of removing the defect. There are three principal methods for the removal of defects: chipping, grinding, and flame gouging.

It is a fact that hardly two foundries will use a similar procedure for the removal of a similar defect, but most foundries will use these three methods to various extents. In general, the small alloy steel foundries tend toward grinding; the large carbon steel foundries toward flame gouging. The three methods and the advantages and disadvantages of each will be discussed separately.

Removal Methods

Chipping. The oldest, and probably still the most generally used, method of removing defects is by chipping. It is usually accomplished by hand with a pneumatic hammer (Fig. 1), using either flat or gouge tools, depending upon the type of defect. The principle advantage of this method is in the removal of small defects. Small cracks and patches of surface sand and shrinkage may be rapidly removed.

The principal disadvantage of this method is the increase in time required to remove large quantities of metal. Another disadvantage is sometimes present, particularly in the smaller castings, when the defect to be removed is inaccessible for proper use of the chipping hammer.

Cracks may be followed by this method, provided that the crack is sufficiently near the center of the chip to cause it to split. Likewise, a crack may be closed by improper chipping so that its presence is difficult to determine unless the excavation is subjected to a magnetic particle inspection or ground smooth in preparation for other methods of inspection.

Due to the foregoing it is usually required that all excavations be checked by some method to assure complete removal of the defect. Grinding is desirable if the excavation is to be checked visually by etching or by radiographing. If the magnetic particle inspection is used, a normally prepared area is gener-

Fig. 1—Removal of casting defect by use of chipping hammer.

This paper was secured as part of the 1945 "Year-'Round Foundry Congress" and is sponsored by the Steel Division of A.F.A.

Fig. 2—Preheating casting with gas torch

ally satisfactory provided, of course, that the type of surface is satisfactory for later repair by welding.

The difficulties of the chipping operation increase with the hardness and toughness. For this reason it is desirable that castings be heat treated by annealing prior to chipping. It follows that the removal of defects from high carbon and alloy castings may be quite difficult.

Factors in Grinding

Grinding. The removal of defects by grinding is used principally on high carbon and alloy steel castings where chipping is not practicable due to hardness or toughness, and in other castings where defects are small and access difficult by the other methods of removal. This method is not used for large defects, unless the analysis of the casting prevents the use of one of the other methods.

Its advantage lies principally with the surface finish that it produces. This surface may be readily checked by any mechanical method of inspection. The disadvantage lies in the fact that it is the slowest method for the removal of defects, and that it is difficult to visually follow the defect during its removal. The possibility of grinding checks in hard materials may also be termed as a disadvantage, as these checks may not be readily visible except by magnetic particle inspection.

Preheating. Preheating is required both b e f o r e flame gouging and welding of castings containing over 0.35 per cent of carbon, and for most alloy grades. Its use is also desirable in lower carbon grades to prevent the formation of cracks if shop or part temperatures are below normal, if manganese and sulphur analysis are abnormal, or if repairs are to be made of large or intricate areas, particularly if the section is of over ¾-in. thickness.

The degree of preheat needed will be approximately the same both for flame gouging or welding. As there are numerous tables published with recommended preheating temperatures required for welding and a few for flame gouging, it is not felt that detailed instructions on this subject are necessary in this paper. Generally, a preheating temperature of 300° F. is required, which is maintained during welding and is followed by slow cooling.

Stress Relief

The purpose of preheating is to eliminate the possibility of cracking, and as the theory applies equally to flame gouging and welding its discussion is felt desirable. In theory, the surface of metal immediately adjacent to the cutting torch or weld metal is first heated to a very high temperature. As the underlying metal is at lower temperatures, it resists the same degree of expansion, resulting in the surface being upset.

Subsequent cooling results in failure due to the inability of the surface to withstand the high stresses involved when the underlying metal resists this contraction. This is particularly true with metals having low ductility, as the more ductile materials will elongate within themselves to relieve or distribute the stresses occurring.

Preheating may be accomplished by a number of different means, among which are preheating in furnaces, either permanent or temporary, by heating torches of gas or oil (Fig. 2), or by electric strip heaters. The latter method is becoming more popular, as heat may be controlled in its location and amount, the procedure gives no objectionable fumes, leaves no residue, and reduces the fire hazard of open torches. It is particularly desirable when large and complicated castings are involved, or when a casting is located within a final assembly.

Flame Gouging. This is one of the most controversial subjects in the foundry. It is the most rapid method for the removal of defects, being variously estimated as being up to ten times as fast as chipping (Figs. 3 and 4). It is claimed that this rapid removal of cracks tends to drive them into the casting.

Theory of Gouging

Theoretically, while the gouging flame is impinging on the casting the surface metal is being heated and expanded, but the adjacent colder metal is resisting this expansion. Therefore, the crack is not apt to progress in heating. Upon cooling, however, it is subject to tensile stresses, and it is at this time that the crack will extend if it still exists, or will originate if metal weaknesses exist within the stressed area.

It is, therefore, important that defects, which may act to increase the existing stresses, be entirely removed before the metal is allowed to cool. Apparently, no satisfactory method of proving whether or not these theoretical conditions are true is available. It is for this reason that this method will probably continue to be controversial.

Although any cutting torch may be used for the removal of defects, certain tips have been developed for this type of work. These tips allow broad and smooth excavations which do not require further chipping or grinding for welding. The tip will depend upon the type of

gas used. Oxyacetylene gas is usually selected, but even city gas may be used, provided that oxygen is present for oxidizing the metal, this being the essential part of the gouging operation.

For the flame gouging of steel castings of up to 0.35 per cent carbon, preheating generally is not required. For castings with carbon contents above this amount, and for alloy castings, it may be necessary to preheat.

The advantage of flame gouging lies entirely in the speed of the operation. It is also the author's opinion that with experience it is the easiest method of following defects to assure complete removal. The fact that this experience is required is the chief disadvantage of the method.

Selection of Operators

Inexperienced operators may cause removal of considerable excess metal due to the speed of this operation or, due to their inexperience, they may not remove sufficient metal to eliminate the defect. In the latter case the defect may be extended further into the casting and require an additional burning operation for its removal. Either of these errors may so increase the cost of repair that the advantages of flame gouging are entirely lost.

If the gouging operation is properly conducted the resulting excavation is satisfactory for any method of checking, including visual inspection. The weld may be deposited on this surface satisfactorily.

Carbon-Arc. Another method of removing defects is by the use of the carbon-arc. This method is considered a variation of flame gouging, and is not generally used but confined to special cases. It differs from flame gouging in that the metal is removed by melting rather than by oxidation. Its chief advantage therefore lies in the removal of defects from high alloys that are difficult to oxidize. Generally, the high alloys of this type do not require preheating.

This method is not recommended for the removal of defects from castings on which flame gouging may be used, as the latter method will furnish a satisfactory and much cleaner excavation more rapidly and with less possibility of further extension of the defect.

The Excavation. With the removal of the defect, two conditions are required of the excavation; (1) that the defect is entirely removed, and (2) that it is weldable.

The soundness of the excavation is commonly assured by visual examination, cold acid etching, or magnetic particle inspection (Fig. 5). Other methods such as the whiting test and the fluorescent tests may be used, but are not generally employed.

The chief disadvantages of the visual examination for assuring soundness is the ease with which tight cracks may be overlooked, particularly on chipped or ground surfaces which may tend to close the defect.

Cold acid etching, as practiced with a 5 per cent nitric acid solution in alcohol and an alcohol wash, will reveal defects principally by the seepage of a dark green solution from the defect to the clean, steel-gray surface resulting from the alcohol wash. The principal disadvantage is that for very tight cracks the etching should be continued for one-half hour. However, for shrinkage and blowholes this method is particularly adaptable due to the speed with which the seepage from this type of defect will occur.

Magnetic Particle Inspection

Magnetic particle inspection of excavations is now generally recognized as the outstanding method for assurance of freedom from cracks and directional defects, both surface and sub-surface. It is not particularly satisfactory for blowholes, etc., which do not have directional properties. This inspection may be conducted by using from 400 to 800 amperes D.C. applied through two prods placed 4 to 8 in. apart.

The application of the prods should be made in at least two directions, 90 degrees apart. Dry powder, either red or black, may be used, and this is applied while the current is passing between the prods. In using this method care must be exercised to keep the voltage low and the contacts good, so that arcing may be held to a minimum. Excessive arcing will cause hard spots that may result in serious difficulties due to the development of cracks from these areas. A switch to break the circuit without drawing an arc is recommended.

"All-over" Method

The "all-over" method of magnetic particle inspection, wherein considerably higher amperages are used with the contacts usually at the extremities of the casting, may be employed in the checking of excavations or other intermediate testing.

However, it is not recommended to check excavations unless better penetration or less arcing due to fewer contacts is desired. For initial or final testing, or where the whole casting is to be inspected, it is highly recommended as it offers an ef-

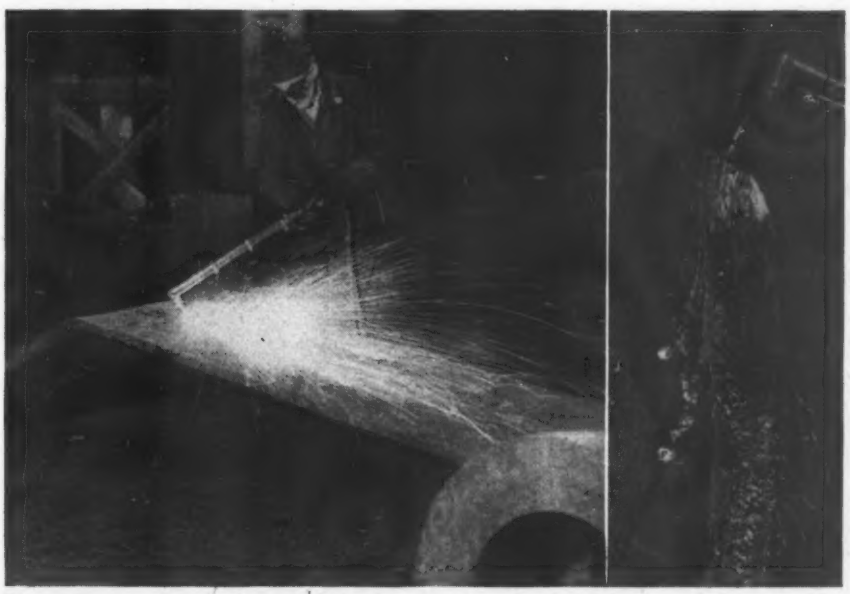


Fig. 3 (left)—Removing casting defect by flame gouging. Fig. 4 (right)—Another view of flame gouging operation.

fective method with great savings in inspection time.

Welding. After the removal of the defect has been assured by a suitable means of examination, it becomes necessary to decide whether welding is necessary or desirable, and if so whether gas, electric or thermit welding should be used (Fig. 6).

It is sometimes entirely unnecessary to weld excavations, due to their size or location within the casting, particularly in machined castings where welding may cause warpage. In fact, in higher carbon and alloy castings which have been machined and cannot be properly stress annealed, it would probably be much wiser to avoid welding if it could be done without affecting the serviceability of the casting.

Stress Development

This statement is made as it is well known that cracks have developed from stresses existing within the hardened area beneath a weld which has not been properly stress annealed. If it is decided to dispense with the welding operation, it must be borne in mind that the excavation must be free of all possible stress concentrations.

This means the removal by grinding of all valleys and ridges developed in chipping, and of all thermal conditions and chemical conditions existing after flame gouging. It is also preferred that the excavation be proved by magnetic particle inspection to verify complete removal of the defect and to assure absence of grinding checks.

If it has been decided that welding repair is necessary, a suitable method of fusion welding must be selected. It is not the purpose to discuss these methods in any great detail, as such a discussion would entail a considerable amount of space.

Welding Methods

The discussion which follows is limited to the general points of interest, as it is felt that all foundries have more or less established welding procedures, but if further information is desired, reference to various publications including the *Welding Handbook* should be made.

Gas Welding. This method has in general been superseded by electric or arc welding, although its use may be advantageous in repair welding of small castings. The disadvantage of this method of welding in large castings is the difficulty and expense of maintaining sufficient heat in the vicinity of the weld and the resulting slowness of the operation.

With small castings this disadvantage may be of so little consequence that the better control and manipulation of the gas torch may justify its selection. The oxyacetylene flame is preferred in this type of welding, although the slower oxygen-hydrogen flame may be used under certain conditions.

Electric Welding. Electric or arc welding is the common method by which steel castings are repaired due to the fact that the arc furnishes a suitable source of heat which is effectively concentrated. There are several ways in which this type of welding is applied. These are by alternating or direct current, the latter by either straight or reversed polarity, and by either carbon or metallic electrodes.

Magnetic Blowing

The use of alternating current has as its particular advantage the elimination of magnetic blowing, which is caused by the return of the magnetic circuit in direct current welding, and in the lower cost of both equipment and maintenance. With suitable power available this method of repair welding should increase in popularity. It is particularly adaptable to deep and narrow repairs.

Reversed polarity direct current is now the most popular method of repair welding and is adaptable to all repairs except where magnetic blowing is excessive. The quality of the deposited metal generally excels that of the straight polarity method. Straight polarity is extensively used where specifications allow its use, due to the ease of application.

Carbon-arc welding has in general been replaced by the metallic arc due to the quality of the deposited metal. This method is fast when using large carbon electrodes, and is a very rapid method for depositing metal, but the deposited metal is poor unless shielded, which is the principle of certain automatic processes. These processes are not adaptable to the repair welding of castings.

Electrode Selection

In each case the selection of the type of electrode used will depend upon the method and the material to be welded. Hot electrodes, either by type or size, are to be discouraged in the welding of enclosed cavities, due to increased stresses on restrained areas. The size of the electrode used depends upon the size of the repair or casting. Three-sixteenths and one-quarter in. electrodes are generally used.

Thermit Welding. The use of

Fig. 5—Checking soundness of excavation by magnetic prod method.

thermit welding (Fig. 7) has been more or less confined to assemblies of large or intricate sections or to the repair of broken pieces. In these cases the weld deposit is unrestrained in that one or both ends are free to contract during the cooling cycle. It is not common practice to use this method to repair large excavations in which the deposit is restrained by surrounding metal.

However, it is practicable to use the method provided that the casting is preheated throughout to a high temperature. The preheating temperature is extremely important and the casting should remain red at the welding face for several minutes after removing the preheating torch.

Thermit welding is faster than any other method of welding, and should be particularly advantageous in the repair of the larger excavations. Its disadvantage lies principally in the high preheating temperatures required.

Special Practices. It sometimes becomes necessary to consider means for the excavating and repair of castings other than the usual excavating by flame gouging, chipping or grinding followed by welding. This applies where the defect is of such an extent that excessive removal or extra long welding time is required.

Welding Special Shapes

In these cases the defective area may be cut out in its entirety, and a rolled plate, pipe or castings of equal or higher properties fitted to the area and welded into position by whatever means is applicable. For example, a plate cut to the size required could be inserted and welded, using the electric-arc method, or a section of pipe might be attached by thermit welding. In the case of an intricate shape, a separate casting could be made and welded into position.

In most cases of this type the area to be repaired is cut out and/or beveled by flame machining or cutting. It is desirable, if possible, that this machining be done with a mechanical set-up rather than by hand.

Another specific casting repair is an edge or protruding part of the casting which failed to run, was porous, or otherwise in need of repair. In these cases, if the area is not too extensive, a plate is tack welded to the outside of the casting and the repair built up against this plate. This necessitates the removal of the plate and the completion of the weld by building up the initial deposit.

Fig. 6—Manipulator for casting repair welding.

Many other repair methods exist, but few of these remove the defect. Some of them are recognized as satisfactory under certain conditions; others are not. Among these methods, drilling a defect and inserting either a welded or machined plug is common, as is also the method of closing porosity by sealing compounds either hydrostatically or by surface application.

Shrinkage and Distortion. A major problem in the repair of castings is distortion caused by the shrinkage of the weld in cooling. This problem can be solved, or the condition at least relieved, by the adoption of a suitable welding procedure.

Shrinkage Compensation

Peening or hammering the weld deposit to compensate for the shrinkage is practiced quite generally, but is difficult to control.

Tack welding or jigs may sometimes be employed to prevent distortion, although these methods promote additional residual stresses within the casting.

Residual Stresses. All castings subject to welding repair have residual stresses which, when excessive for any particular section, will cause distortion. The presence of distortion indicates the mechanical relief of stresses which locally may exceed the elastic limit.

Preheating, welding technique, peening, overstressing, etc., may be designed to reduce stresses resulting from repairs, but the complete elimination of stresses is doubtful. This is the reason why stress anneal or heat treatment is felt to be desirable after repairing.

Section Welding

A noteworthy example of welding technique to reduce residual stresses is the procedure for welding a long, narrow and deep excavation. In this case the excavation will be divided into sections and each welded separately. This practice eliminates the high stresses along a long and narrow weld deposit which is not thick enough to withstand them, and substitutes a method wherein a strong weld over-stresses the intermediate voids and assists in the reduction of residual stresses.

Residual stresses are usually estimated, and this estimate is based on the relative depth of the weld deposit to the thickness of the section. In general, ratios of more than one to five indicate the need for further heat treatment.

Heat Treating. The optimum in heat treatment of repaired castings would consist of a preliminary treatment or anneal prior to the removal of the defect, preheating prior to

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, A.F.A., 222 West Adams St., Chicago 6.

and during welding, and subjection to final heat treatment after the completion of the repair. This procedure is neither practicable nor economical in many cases, and the usual practice in most foundries is to complete heat treatment before repairing and to follow the repairs with a stress annealing treatment to remove stresses developed in the repairing cycle.

This practice is generally recognized as being satisfactory and is usually specified. Size, shape and analysis of the casting, as well as the type of repair, should be considered in the establishment of the treating cycle.

Stress Annealing. The plastic strength of metal begins to be affected at temperatures above 400° F., and any residual stresses in excess of the maximum strength at that particular temperature will be relieved by the plastic upsetting of the metal.

Stress relieving temperatures will depend upon the material and other conditions, but in general the desired temperatures are in the neighborhood of 1100° F. After holding at this temperature for a sufficient length of time, depending upon the section, it will be found that the residual stresses have been practically eliminated. Longer holds at lower temperatures have also been found to be effective, although the higher temperatures are to be preferred.

Cooling from the stress annealing temperature is of particular importance in the case of most castings, as different sized sections of the casting will cool at varying rates, resulting in the setting up of new residual stresses.

Frequently, small repairs are not stress relieved, and hard spots will develop in machining either from the weld or adjacent metal in the case of high carbon or alloy castings, or from arcing either in the magnetic particle inspection or from striking welding arcs away from the repair area. This condition can be eliminated by proper stress anneal.

Rough Machining. This is not a repairing operation, but it is an operation which should definitely be taken into consideration in any repairs. If the casting is to be machined, many surface imperfections will be removed by the roughing cuts and internal repairs will be made more readily accessible or reduced in amount, so that wherever possible it is desirable to rough machine before repairing.

Intermediate and Final Tests. During the welding of large excavations it is sometimes desirable that tests be made to assure freedom from cracks, and it is frequently specified that each layer be magnetically tested by the prod method in at least two directions. No other method of inspection is applicable at this point due to surface conditions and/or time of inspection.

Upon completion of the repair, it is usually specified that the repaired areas be inspected. In some cases this refers to all repairs; in other cases to repairs which exceed a certain proportion of the thickness of the section.

Inspection should be made by radiographic means, either gamma or x-ray, depending upon the thickness of the section. This is the only method for the location of subsurface welding defects such as porosity, slag inclusions, and poor fusion.

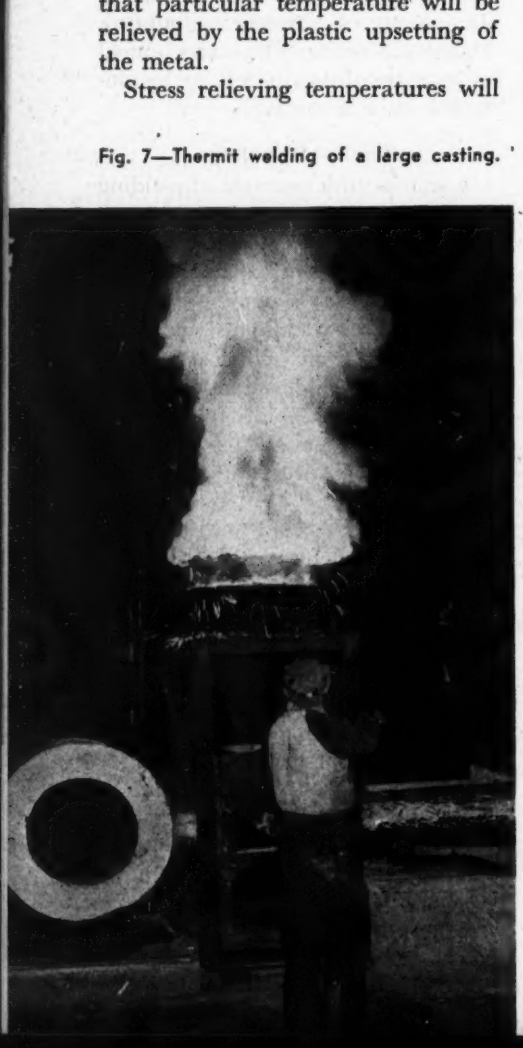
Cracks in either the weld or base metal usually extend to the surface after the repair has cooled, and their identification by magnetic particle or other methods of inspection is not difficult. Final inspection of the casting should be made after all repairs and treatment have been completed to assure a quality product.

With the determination of the presence of any discontinuity, the work reverts back to the introduction of this paper, which discusses whether or not a certain discontinuity is a defect. If it is interpreted as a defect, the procedure of repair is repeated until all repairs have been determined to be satisfactory for the purpose intended.

Acknowledgments

The author wishes to acknowledge the assistance of A. P. Spooner, Metallurgical Engineer; E. R. Howells, Foundry Superintendent, and others of the Bethlehem Steel organization, in the preparation of this paper.

Fig. 7—Thermit welding of a large casting.



Army-Navy Liquidation Sells Overseas Surplus

A joint Army-Navy Liquidation Commission has been established in Washington, D. C., for the disposal of overseas surplus war materials. This commission will sell goods to individuals or companies, but sales must be conducted through field commissioners, by mail or an overseas representative. Some 4,000,000 items will be declared surplus and these items are located in warehouses and depots all over the world. Interested parties seeking information should contact Public Information Division, Army-Navy Liquidation Commissioner, New War Dept. Bldg., Washington 25, D. C.

Austenal Laboratories Obtain Army-Navy "E"

AUSTENAL Laboratories, Inc., has announced that their New York plant has been presented the Army-Navy "E" production award.

NON-DESTRUCTIVE TESTING
of Steel Castings
Report of the Steel Division Committee of A.F.A.

• Methods developments and progress in setting up standards for non-destructive testing are reported to members of A.F.A. Steel Division. The bibliography of recent publications contains articles on non-destructive testing of steel castings, technique and fundamentals related to radiography of steel castings.

DURING the year from April 1944 to April 1945 the A.F.A. Steel Division Committee on Non-Destructive Testing took an active part in matters connected especially with the magnetic particle testing of steel castings. One member of the committee, A. P. Spooner of Bethlehem Steel Co., took the lead in arranging and preparing the drafts on a standard practice for magnetic particle testing which was submitted to the American Society for Testing Materials. All the members of the A.F.A. committee were asked to review the drafts and submit comments. The material so prepared has been set up as a standard procedure specification E-222 of the ASTM. It is the belief of your committee that this procedure is an excellent one and will better enable steel foundries to carry forward their studies in connection with non-destructive testing. Those foundries that have not as yet entered the magnetic powder inspection field would do well to study the procedure of E-222, as it is believed that they will be materially benefited by this clear and authoritative recommended procedure.

The committee realizes that its review by questionnaire of the status of the use of non-destructive testing in the steel casting industry is long overdue. However, in view of the production requirements for steel castings during the past year as a result of the war, it was deemed advisable to again postpone asking the foundries to execute a long questionnaire on the subject of non-destructive testing. This study will be undertaken at the first opportune moment.

The committee is of the opinion that the use of non-destructive testing methods has reached a new high in the steel casting industry during the past year. In fact, it would be used to even greater extent than it now is, if a greater supply of radiographic film were available.

There have been no new developments during the year in radiographic standards. Committee E-7 of the ASTM has not as yet come forward with radiographic standards. This committee has, however, clarified its definitions regarding the appearance of defects as illustrated by radiography.

During the 1944 A.F.A. Annual Meeting, two excellent papers on non-destructive testing were presented by J. F. Cotton and P. Ffield of the Bethlehem Steel Co. It was planned to hold a symposium on non-destructive methods at the 1945 A.F.A. Annual Meeting. This symposium was not held owing to the O.D.T. restriction on meetings; however, all the papers scheduled for presentation will be published in A.F.A. publications.

In line with the policy established during the past two years, this report presents a review of only those articles the subject of which is related to the non-destructive testing of steel castings. These articles are listed as an appendix to this report.

COMMITTEE ON NON-DESTRUCTIVE TESTING

C. W. Briggs, *Chairman*
R. A. Gezelius, *Vice-Chairman*
Philip De Huff, Jr. — A. P. Spooner
John W. Juppenlatz — R. H. Frank
Werner Finster — L. W. Ball

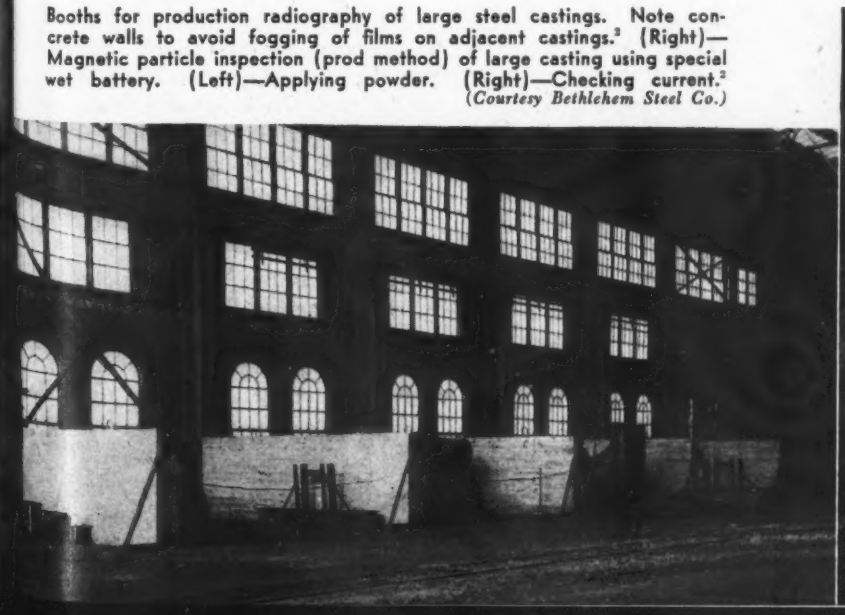
Appended Bibliography on Non-Destructive Testing

Articles on the Non-Destructive Testing of Steel Castings

1. J. F. Cotton, "Magnetic Powder Inspection of Large Castings," TRANSACTIONS, American Foundrymen's Association, vol. 52, pp. 205-231 (1944). A quantitative evaluation is given of the variables which govern magnetic powder inspection. The evaluation shows that a standardized technique must be established before standards of magnetic powder inspection can be prepared.

2. P. Ffield, "Conditioning of Steel

Booths for production radiography of large steel castings. Note concrete walls to avoid fogging of films on adjacent castings.[2] (Right)—Magnetic particle inspection (prod method) of large casting using special wet battery. (Left)—Applying powder. (Right)—Checking current.[2] *(Courtesy Bethlehem Steel Co.)*



Castings to Standards of Quality," TRANSACTIONS, American Foundrymen's Association, vol. 52, pp. 173-204 (1944). Application of non-destructive tests; influence of non-destructive testing on the conditioning of castings; radiographic standards of acceptability; practicability and interpretations of magnetic powder standards; significance of cracks in high-pressure, high-temperature castings; magnetic powder inspection as a complement to radiography; flame excavation of defects; magnetic inspection of flame-gouged areas.

3. C. L. Frear, "Radiographic Specifications and Standards for Naval Materials," TRANSACTIONS, American Foundrymen's Association, vol. 52, pp. 1078-1110 (1944), and *Industrial Radiography,* Spring, 1944, pp. 33-36. In a summary of the inspection by the Navy, the history of its use as a means of inspection is presented. A list of the different classes of castings requiring this inspection is given, also the influence of the requirement upon the steel foundry industry. The specific requirements of the Navy, process approval and radiographic standards are discussed. A table of radiographic standards is included.

4. R. Taylor, "Radium Radiography in Industry," *Steel,* April 10, 1944, pp. 108, 110, 112. A review of the use of radium in the inspection of castings that are to withstand high pressure and temperatures, such as steam boilers, marine equipment, hydraulic power installations; also for the inspection of pilot castings. Two methods for industrial use are described.

5. R. Taylor, "The Value of Radiographic Inspection to the Small Foundry," AMERICAN FOUNDRYMAN, May, 1944, pp. 2-4. A discussion of the value of this method of inspection as a cost saver in the small foundry. As the value of the method is not limited to the detection of imperfect castings, it can be used as a means of improved foundry control for the production of sound castings.

6. "Two Million Volt X-ray Tube for Thick Steel Sections," *The Iron Age,* Nov. 2, 1944, p. 62. Description and photograph of the 2-million volt x-ray tube with which heavy steel objects up to one foot in thickness can be radiographed with relatively short exposures.

7. C. L. Frear, "Magnetic Powder Inspection of Castings," ASTM Bulletin, Dec., 1944, pp. 12-14. The use of magnetic powder inspection on valves and fittings, and hull castings. A discussion of the interpretation of indications shown by various casting defects, magnetic powder procedure for steel castings, magnetizing equipment, and magnetic powder versus radiography.

Articles on Technique and Fundamentals That Are Related to Radiography of Steel Castings

1. A. Morrison and E. M. Nodwell, "Exposure Graphs for Radium Radiography of Steel," ASTM Bulletin, March, 1944, pp. 25-30.

2. A. Morrison and E. M. Nodwell, "Use of Film to Measure Exposures to Gamma Rays," ASTM Bulletin, March, 1944, pp. 31-32, and *Industrial Radiography,* Summer, 1944, pp. 31-32.

3. S. Maddigan and B. Zimmerman, "Microradiography—A New Metallurgical Tool," *Metals Technology,* Feb., 1944, TP 1683, 26 pp.

4. "Co-Operative X-ray Research," *Steel,* March 20, 1944, p. 96.

5. R. Taylor, "Radium Inspection of Metals," *Steel,* April 3, 1944, pp. 122, 124, 166, 168, 170.

6. R. Taylor, "X-ray Process Engineering," *The Foundry,* May, 1944, pp. 74, 141-142.

7. G. Close, "Organic Coating Aids Magnetic Inspection," *The Iron Age,* Aug. 31, 1944, p. 4.

8. C. Jenni, "Stopper Heads X-rayed to Eliminate Pouring Trouble," *The Foundry,* Sept., 1944, pp. 68-70, 208.

9. L. W. Ball, "Radiographs—What They Tell Designers," *Machine Design,* Dec., 1944, pp. 135-140.

10. Symposium on Magnetic Particle Testing: A. V. de Forest and C. E. Betz, "Equipment for Magnetic Particle Inspection." H. H. Lester, "Magnetic Particle Inspection, Particularly from the Standpoint of Specification Requirements." E. O. Dixon, "Magnetic Particle Inspection of Aircraft Parts." L. B. Jones, "The Magnetic Particle Test as Utilized by the Railroads." A. P. Spooner, "Specifications and Procedures." C. L. Frear, "Magnetic Powder Inspection of Castings." C. J. Boyle, "Magnetic Particle Inspection of Forgings." E. A. Snader, "Miscellaneous Applications of the Magnetic Particle Test." ASTM Bulletin, Dec., 1944, pp. 7-16.

11. L. W. Ball, "Interpreting Aircraft Radiographs," *The Foundry,* Feb., 1945, pp. 82-85, 192, 194, 196, 198.

12. J. Bland and E. Banks, "Adjustable Radium Capsule Support," *Industrial Radiography,* Winter, 1944-45, pp. 23-25.

13. E. Meschter, "A Simplified Method of Film Evaluation," *Industrial Radiography,* Winter, 1944-45, p. 35.

ENGINEERING SCHOOLS

Committee Prepares National Program

THE Executive Committee of the Committee in Cooperation with Engineering Schools met in Cleveland, October 2, to discuss a national program for acquainting engineering students with the foundry industry.

Attacking the problem of teaching all engineering students the proper applications for castings, and of attracting some students into the industry, the committee is working along several well defined lines. Research projects dealing with problems important to the industry will continue to be suggested to schools with appropriate equipment and qualified personnel. Recommendations for improvement of college foundry courses, teaching aids and exhibits will be developed.

Talks delivered by local foundrymen before groups of engineering students are expected to be popular because so few students have contact with industrial foundry practice. Outlines of talks and slides are in preparation.

The variety of positions available to student engineers in the foundry industry become apparent during the discussion of foundry procurement of engineering graduates. In addition to casting design, testing and research departments, engineers are needed to an increasing degree as a result of mechanization of foundries. Metallurgists and engineers often are desired as superintendents and for similar positions. Metallurgists and chemists are found in greater numbers in the control and development laboratories which more and more foundries are establishing. Many engineers would make good salesmen and purchasing agents; they also are found in safety and in methods departments.

Acquainting Engineers

Training graduate engineers in industrial practices and acquainting them with the organization and operation of the various departments of the plant in which they work is particularly important, it was brought out. The outline of a course for within-industry training of college graduates including work in every department was discussed. The necessity for a single plant official to execute the program was stressed.

The Committee in Cooperation with Engineering Schools expects to secure the assistance of local A.F.A. chapters in promoting this work in nearby colleges and universities. Many chapters now have Educational Committees which are in contact with engineering schools.

GRAY IRON FOUNDERS

Holds 17th Annual Meeting in Chicago

MEETING to discuss problems of foundry management the Gray Iron Founders' Society held its 17th Annual Meeting, a Peacetime Production Conference, October 23 and 24 at the LaSalle Hotel, Chicago. Talks and discussions by members of the society included sound costing methods and application, industrial relations and personnel problems, and production control.

A.F.A. Members Rewarded

The luncheon meeting held October 23 featured a talk on the atomic bomb, and the presentation of Gray Iron Founders' Society Awards for distinguished service to the government and gray iron foundry industry. Cited for their wartime services and awarded a beautifully hand-lettered and illuminated certificate were Edward P. Buchanan, Pittsburgh Coke & Iron Co., Pittsburgh, Pa., Assistant to the Chief, Pig Iron Section, War Production Board, August 15, 1941 to February 1, 1944; A. Douglas Hannah, associated with WPB since January 21, 1942 to October 31, 1945, Chief of the Forgings and Castings Branch; Edward C. Hoenicke, Eaton Mfg. Co., Detroit, in charge of Gray Iron Castings Section, WPB, January 4, 1944 to July 27, 1944. William Kerber, The Hanna Furnace Corp., Buffalo, N. Y., who starting with WPB in September 22, 1941, continued in government service until April 29, 1944, most of the last year as Chief, Raw Materials Branch, received a certificate as did Donald J. Reese, Campbell, Wyant & Cannon, Muskegon, chief of several sections, and consultant, from April 13, 1942 to February 16, 1945; and Frank G. Steinebach, Editor, *The Foundry,* in 1941-42 Chief, Foundry Equipment and Supplies Unit, OPA and WPB. Messrs. Hoenicke, Kerber, Reese and Steinebach are members of A.F.A.

Howard F. Taylor, metallurgist, Naval Research Laboratory, Washington, D. C., talked at one of the sessions on the importance of research to gray iron foundry progress. Mr. Taylor will conduct research at Massachusetts Institute of Technology, Cambridge, Mass., under the auspices of the Gray Iron Founders' Society.

Speaking at the October 24 luncheon session the Honorable Alexander Wiley, Senator from Wisconsin, forcefully discussed some of the bottlenecks in reconversion. Dr. David D. Henry, president, Wayne University, Detroit, presented a lucid description of the problems the foundry industry faces in recruiting and training engineers.

Officers and directors were elected at this meeting and the following Association members took office: H. L. Edinger, vice-president, was elected president of the Society. Mr. Edinger, Barnett Foundry & Machine Co., Irvington, N. J., is an A.F.A. member. Elected as vice-president was George H. Alten, Alten's Foundry & Machine Works, Lancaster, Ohio. Mr. Alten also is an A.F.A. member and active in the Central Ohio chapter. Assuming the position as directors were: C. R. MacGrail, president, Texalloy Foundry Co., San Antonio, Texas, whose company is an A.F.A. member and of the Texas chapter; and E. C. Hoenicke, Eaton Mfg. Co., Detroit, Chairman, A.F.A. Detroit chapter.

Castings Inspection Men Develop Meeting Program

THE regular monthly meeting of the Inspection of Castings Committee was held at the headquarters office on October 26. Presiding was E. G. Leverenz, American Steel Foundries, East Chicago, Ind. The committee was formed some two years ago, with its first appearance at the Buffalo Convention in 1944. The committee has planned to have a program of two sessions for the 1946 meeting, the first session to be devoted to presentation of papers on phases of inspection of castings, with three papers to be presented and discussed. The second session will be a panel discussion, with three discussion leaders to develop specific problems of foundry inspection departments. This panel discussion will attack the subject from three angles, the inspection department, foundry management, and casting sales department.

The committee is working on the development of a Casting Inspection Manual. Sections of this have already been published in the AMERICAN FOUNDRYMAN. In its work the committee emphasizes the need for considering the ultimate user of castings, as this is felt to be very important in the keen competition period which is facing the industry.

Magnesium Association Elects Christiansen

THE Magnesium Association at its second annual meeting held in the Waldorf Astoria Hotel, New York on October 2 and 3, elected as President, Edward S. Christiansen, and as Vice-President, Anthony Cristello. Both Messrs. Christiansen and Cristello are A.F.A. members, Mr. Christiansen being president, Edward S. Christiansen Co., Chicago, and Mr. Cristello, foundry manager, Eclipse Aviation Div., Bendix Aviation Corp., Bendix, N. J.

Manley E. Brooks, Dow Chemical Co., Bay City, Mich., and Dan W. Moll, Hills McCanna Co., Chicago, were elected directors. Mr. Brooks is a member of the A.F.A. Aluminum and Magnesium Division Executive Committee, and Mr. Moll is the official representative of the Magnesium Association on our A.F.A. Aluminum and Magnesium Executive Committee. This close cooperation of the two associations has been effected to promote greater interest in technical problems of magnesium castings.

Material Handling Men Organize New Society

AT a dinner meeting held in the Roosevelt Hotel, Pittsburgh, Pa., October 8, a group of men interested in material handling voted to form a society. Information about this new group may be obtained from Richard Rimbach, Temporary Secretary, 1117 Wolfendale St., Pittsburgh 12, Pa.

Fig. 5—Radiograph showing shrinkage zone in section of intake rocker box from an air-cooled cylinder head casting.

DENSITY OF Light Alloy Castings

By M. W. Daugherty and L. W. Kempf,
Aluminum Research Laboratories, Aluminum Co. of America, Cleveland.

• This paper discusses the possible errors involved in the use of density determination for measuring the soundness of castings. It suggests some methods for reducing these errors to a minimum and illustrates the application of the methods. Some observations are made on the practical significance of variations in density of castings.

DENSITY determinations have long been used in the copper industry as a measure of the soundness of castings. The literature abounds in references describing investigations in which the densities of copper and copper alloy castings vary over ranges as high as 8 or 10 per cent. Density determinations are also made as a matter of routine in some plants producing copper and copper alloy ingots for working.

It is generally agreed, at least in the literature, that the sources of unsoundness in copper castings are shrinkage and the evolution of gas during the solidification of the metal.

Aluminum alloy castings are known to suffer from unsoundness due to the same causes. By analogy, it would appear that density determinations might be of use in the examination of the soundness of aluminum alloy castings.

The principal non-destructive method in use at present for the determination of the soundness of aluminum alloy castings are radiography and fluorescent oil-black light examination.

Radiography is probably the most generally useful of the non-destructive tests. It has the advantage of defining the voids as to size and location, but has the drawback of relatively high cost and a sensitivity which is limited to about 3 per cent of the section thickness being examined. Also, radiographic examination does not yield quantitative values which may be used as an independent index of soundness.

Examination by the fluorescent oil-black light procedure is limited to the determination of voids which have an opening to the surface of the object being examined.

Preliminary determinations on miscellaneous aluminum alloy sand castings indicated variations in density of up to 3 per cent. Since the density determination, even on relatively large objects, generally can be made with an accuracy of at least 0.1 per cent, using the usual method of weighing the specimen in air and suspended in a liquid, it appeared that density determinations might be useful in laboratory investigations and, perhaps, under

This paper was secured as part of the 1945 "Year-'Round Foundry Congress" and is sponsored by the Aluminum and Magnesium Division of A.F.A.

some conditions, even for commercial inspection. It immediately becomes desirable to determine the limits of significant measurement.

Determination of Density

The density determinations in the investigations to be described were made on four balances of 0.4-, 1.5-, 5- and 35-lb. capacity, respectively. With each specimen the balance of smallest possible capacity was used. The precision of the balance was such that the ratio of the mean weight of a specimen, observed in repeated weighings, to the maximum deviation from the mean was in no case less than 4000 to 1.

With a given balance, the ratio decreases with the weight of the specimen. Consequently, the precision of the balance must be such that a ratio of at least 4000 to 1 is obtained with the lowest weight of specimen for which the balance will be used. These conditions confine the expected variations in repetitive weights to within 0.025 per cent, which is adequate to permit keeping the maximum error in the density determination below 0.1 per cent.

The immersion liquid used was a 0.04 per cent solution of a wetting agent in tap water. The wetting agent is quite necessary, otherwise difficulties are encountered because of air bubbles clinging to the castings. The immersion liquid was maintained within 5° C. of a specific temperature and all determinations reduced to a standard temperature.

The volume coefficient of thermal expansion of the alloy being investigated, and the temperature coefficient of density of the immersion liquid are, of course, necessary for the reduction of determinations to a standard temperature.

Determination of Void-Free Density

For the determination of the volume of voids in a casting, it is necessary to know the density of the casting if free from voids. The determination of the void-free density of a specific casting is a somewhat complex problem. It is not sufficient to determine the density of a single void-free specimen of a standard alloy experimentally, and use the value obtained as the established density of the alloy.

The effect on density of variations in composition among random castings, within acceptable specification limits, would introduce intolerable errors. For example, with 195 alloy the permissible variation in composition within the Army-Navy Aeronautical Specification AN-QQ-A-390 would make possible a variation of 1.63 per cent in density, which is more than half the expected maximum variation in density in commercial sand castings of this alloy.

If the average chemical composition of a casting is accurately known and the void-free density is calculated by the formula for the density of mixtures, assuming that the alloy is merely a mixture of its constituent elements, the density so calculated is, in most cases, lower by a few tenths of a per cent than the density determined on a specimen of the same composition which has been forged or otherwise worked to a reduction of 80 per cent or more.

This difference results from the contraction in volume which usually accompanies the alloying of two or more metals. The calculated density can be satisfactorily adjusted to actual void-free density by applying a correction factor based on an experimental determination on a worked specimen of the alloy.

Once the proper correction has been established for any specific composition within the specification limits of a standard alloy, that correction can be used without objectionable error for any other analyzed heat of that alloy, in view of the relatively small variations in composition within specification limits. Unfortunately, in most production procedures the exact chemical composition of each specific casting is not known, even though the routine does insure each casting being within specification limits.

Void-Free Specimen

The shortcomings of the foregoing described methods of establishing the void-free density of a casting led to the development of a procedure which was utilized in these investigations. A portion of the same batch melt, well stirred, from which the casting is made is poured into a small metal mold of such design that the casting is practically free from voids.

Figure 1 illustrates a casting made in a mold which has been found satisfactory for standard density specimens. For an even higher degree of accuracy, such a standard

Fig. 1—Density cone casting showing density specimen before and after hot pressing. Outlined section indicates part used as density specimen.

density specimen may be hot pressed or otherwise worked to eliminate any small amount of voids. Experience with many hundreds of these standard density specimens indicated that, even without pressing, they rarely contain more than 0.15 per cent voids.

The standard density cone, or specimen, is, in most cases, poured at the same time as the casting on which the void determination is to be made, but in some cases it is poured from a remelt of the whole casting. The remelt of part of a casting cannot be used for a standard density specimen to represent the whole casting without danger of serious error from segregation.

Complex Castings

With a complex casting involving many differences in section, and thus markedly different solidification rates, variations in copper concentration as high as 0.75 per cent may occur in the case of aluminum alloys containing 4 to 8 per cent of copper. For the same reason, the analysis of filings or machinings from a casting cannot be used for an analysis upon which to base a calculation of void-free density.

In utilizing the standard density specimen for the establishment of the void-free density of a specific casting, possible error from variation in microstructural condition between the standard specimen and the casting must be considered.

The density of an aluminum alloy varies with the distribution of the alloy elements between the aluminum solid solution and the precipitated form of the specific elements. Such variations in density may amount to as much as 0.5 per cent, but can be completely eliminated by determining the density of both the casting and its accompanying standard specimen in the annealed condition.

By properly recognizing the previously discussed sources of error, percentage void determinations can be made with a total maximum error of 0.2 per cent. The usual or average error would be much less than this, perhaps 0.06 per cent. This order of error appears to be satisfactory for the examination of light alloy castings.

The determination of the practical significance of variations in density of commercial castings is not simple. A number of approaches to the problem have yielded useful data from which a fairly satisfactory picture of general effects can be constructed; however, it must be confessed that the assignment of quantitative values to the various factors involved is, as yet, impossible.

Molding Method

In one investigation, 88 specimens of a cylinder head casting for an air-cooled radial aircraft engine were examined. These castings were all from a pattern which had been in fairly large production for a considerable period of time. The castings were made in dry sand molds by methods which have become conventional for this type of production.

The casting was molded in a vertical position, the open end up and the rocker boxes down. A ring riser extended upward from the flange, with enlargements over each of the rocker boxes. The molten metal was poured from two hand ladles simultaneously directly into the risers.

All of the 88 specimens had been scrapped for mechanical reasons, such as core shift, accidental undercutting during cleaning, etc. The castings were numbered arbitrarily from one to eighty-eight, and the density of each determined as described in the foregoing paragraphs. The void-free density of each head was determined by remelting each casting separately and pouring a density specimen from every melt.

The density standard specimens were also hot pressed to insure the elimination of such voids as might be present in the small chill-cast specimens. The results of these determinations are presented in Fig. 2, bottom line of graph. It will be noted that the voids varied mostly between 0.90 per cent and 1.85 per cent, with three castings below and five above this range.

It has become a fairly general practice with aircraft engine manufacturers to specify the maximum amount of visible pinhole porosity which is acceptable on machined surfaces of this type of casting. In a common method of producing the castings, the open or barrel end is upward in the mold, and a continuous riser connects to the open end.

Pinhole Porosity

Some manufacturers judge the amount of pinhole porosity in a specific casting by very carefully machining the bottom surface of this ring riser and visually estimating the amount of pinhole porosity by comparison with accepted standards. A similar rating was made on each of the 88 cylinder heads by cutting the flange section from the cylinder head and machining the surface which would be adjacent to the ring riser, followed by comparing the porosity visible on the machined surface with arbitrary standards numbered from one to twelve.

The flange sections were also

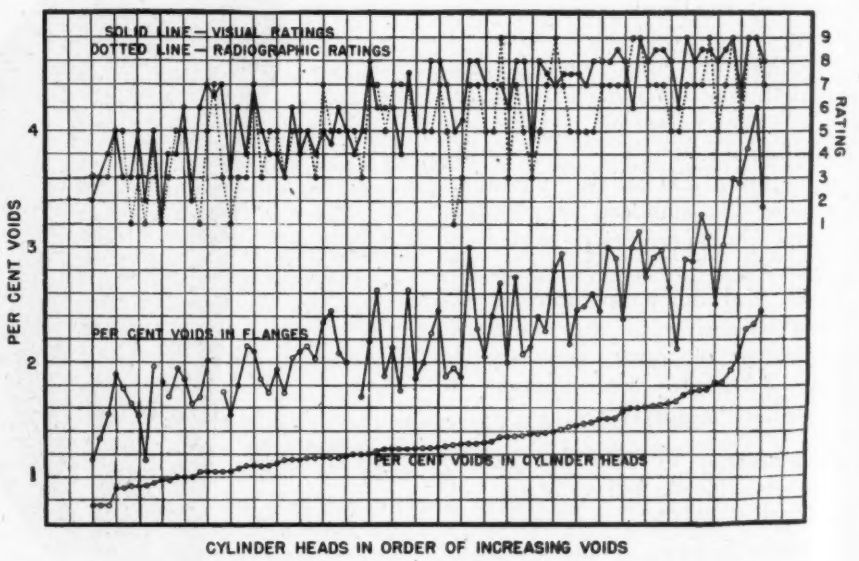

SOLID LINE — VISUAL RATINGS
DOTTED LINE — RADIOGRAPHIC RATINGS
PER CENT VOIDS
RATING
PER CENT VOIDS IN FLANGES
PER CENT VOIDS IN CYLINDER HEADS
CYLINDER HEADS IN ORDER OF INCREASING VOIDS

Fig. 2—Correlation of percentage of voids in 88 aircraft air-cooled cylinder head castings with percentage of voids in the flanges, with radiographic porosity ratings of the flanges, and with visual porosity ratings of machined surfaces of the flanges.

radiographed, as is done by other manufacturers, and the percentage of voids determined separately for each. It will be noted from Fig. 2 that there is a general correlation between the percentage of voids in the cylinder heads, as a whole, and the percentage of voids in the flanges, the visual ratings of porosity on machined surfaces and the radiographic ratings, in that the trend curves for all four examinations are roughly parallel. However, the correlation between individual specimens in the four types of rating is not impressive.

To further examine the distribution of voids in these 88 castings, a number were sawed into sections, as indicated in Fig. 3. Figure 4 illustrates diagrammatically the variation in percentage of voids in the separate sections of six of the castings. The voids in all of the sectioned castings followed the same general distribution. The uniform pattern of distribution of the voids in each head testifies to the absence of substantial amounts of segregated voids.

The separate sections of the 19 sectioned heads were radiographed to further search for segregated voids. The only localized unsoundness found was shrinkage in some of the web sections of the intake rocker boxes. This type of shrinkage is illustrated in the print from the radiograph, Fig. 5. This was the most extensive area of localized unsoundness found in the web sections radiographed.

The percentage of voids in the entire casting, No. 16, was 0.95 per cent, and the percentage of voids in the intake rocker box section was 1.1 per cent. A per cent void determination in the section of the intake rocker box containing the shrinkage showed that the shrinkage accounted for only 0.10 per cent voids in the rocker box and 0.01 per cent voids in the whole head.

It must be concluded, therefore, that the principal significance of the variation in voids in this lot of cylinder head castings is that it reflects the variation in general pinhole porosity. It is known that the principal factor in the formation of general pinhole porosity in aluminum alloy castings is the concentration of gas in the melt.

To further determine the variation in percentage of voids in commercial light alloy castings, a number of castings were taken at random from production and the percentage

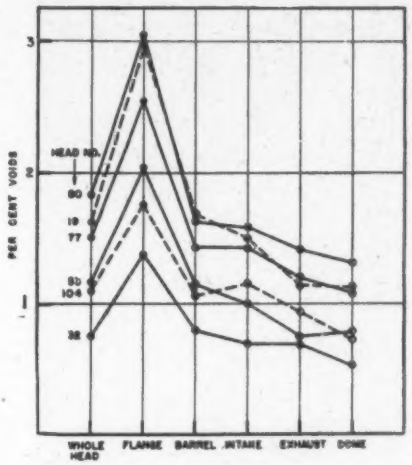


Fig. 4—Sketch showing percentage of voids in various sections of six aircraft air-cooled cylinder head castings.

of voids determined. The results are given in Table 1. Aluminum sand castings and semi-permanent mold castings appear to have about the same average percentage of voids.

The aluminum permanent mold castings are definitely lower in voids than the sand castings, in agreement with general experience. The die castings contain substantially more total voids on the average than the other types of castings. Unfed shrinkage voids and entrapped air are probably responsible for this effect, which is more marked with magnesium than with aluminum.

The magnesium base alloy castings are interesting in that the sand castings have the lowest average percentage of voids, being considerably lower than the average percentage of voids of any of the types of aluminum castings. The magnesium alloy permanent mold castings contain generally somewhat more voids than the sand castings but, here again, the magnesium alloy castings are lower in percentage of voids than the aluminum alloy castings.

However, the magnesium die castings contain more voids than any of the aluminum castings. It has been long observed that magnesium castings usually contain no general porosity arising from the precipitation of gas during solidification, and that any voids present are caused by localized shrinkage. The data in Table 1 support this view.

It has been observed that the amount of general porosity visible on the machined surface of aluminum alloy castings varies inversely with the rate of solidification

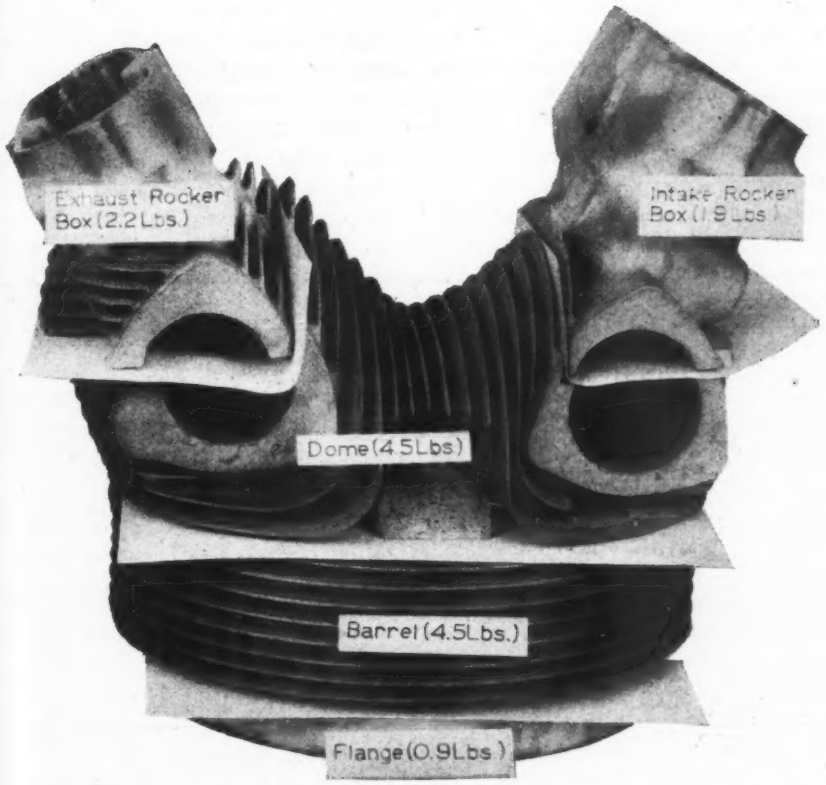


Fig. 3—Aircraft air-cooled cylinder head casting sawed into five sections for determination of the distribution of voids.

Fig. 6—Three sections from an aluminum alloy sand casting. Surfaces are specially machined to fully reveal porosity. (Left) ¾-in. section, 0.68 per cent voids. (Center) 1½-in. section, 1.32 per cent voids. (Right) 3-in. section, 2.52 per cent voids.

of the sections. Thus, heavy sections in a casting usually show more pinhole porosity than thin sections in the same casting, and permanent mold castings generally show much less pinhole porosity than sand castings.

This is illustrated by Fig. 6, which shows the appearance of the machined surface of a ¾ in. thick, a 1½ in. thick, and a 3 in. thick section from the same sand casting. It will be noted that the percentage of voids varies in the same way as the amount of visible pinhole porosity. High rates of solidification appear to inhibit the precipitation of gas during solidification of aluminum alloys.

It is suggested that similar effects obtain in copper base alloy castings where, as demonstrated by Rowe,[1] 5 per cent of voids may be present in bronze sand cast gear wheels, while similar castings more rapidly cooled, as when made in permanent molds or by the centrifugal process, will contain not more than about 1 per cent of voids.

Effect of Variation in Density on Mechanical Properties

In one experiment, standard tensile test specimens and fatigue test specimens were cast from the same lot of 355 alloy, three portions of the melt having been treated in such manners as to give rise to a different concentration of gas in each. All specimens were heat treated to approximately the commercial T6 condition.

The results of the tensile tests and the void determinations on the fatigue specimens are given in Table 2. The results of the fatigue tests are shown in Fig. 7. The fairly wide variation in percentage of voids brought about no significant variation in mechanical properties.

In the foregoing series of fatigue tests, the test sections of the specimens were not machined. In another series of fatigue tests, the results of which are given in Fig. 8, the test sections were machined all over, and here, in some ranges of stress, the specimens with the higher volume of voids gave somewhat lower fatigue properties.

However, even in this series of tests the difference in fatigue strength between high and low porosity specimens is not much greater than the general scatter in any one series.

In a series of full scale fatigue tests on cast cylinder heads performed under conditions of temperature and stress distribution ap-

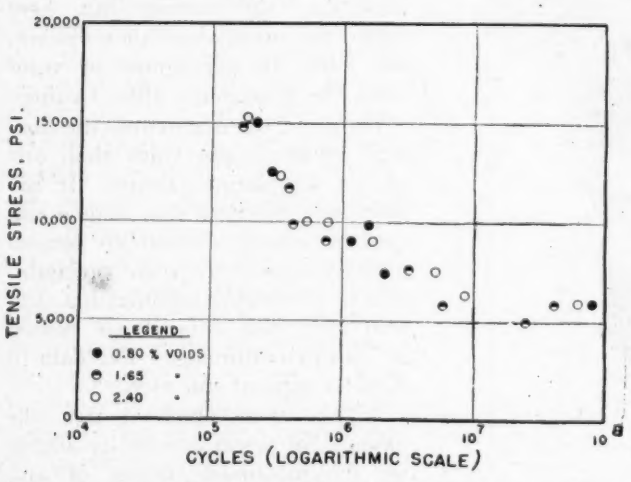


Fig. 7—Results of direct stress fatigue tests of sand cast specimens of 355-T6 alloy. Test section, ¼ in. x 7½ in. with as-cast surface. Minimum stress = zero.

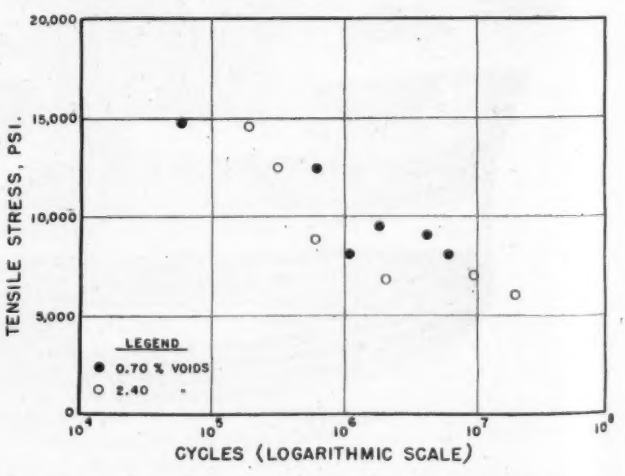


Fig. 8—Results of direct stress fatigue tests of sand cast specimens of 355-T6 alloy. Test section, ¼ in. x 5½ in. with machined surface. Minimum stress = zero.

Table 1

PERCENTAGE OF VOIDS IN COMMERCIAL LIGHT ALLOY CASTINGS

Base of Alloy	*Type of Casting*	*No. of Castings*	*Weight Range, lb.*	*—Voids, per cent—* *Max.*	*Min.*	*Ave.*
Aluminum	Sand	37	0.7-82	3.00	1.11	1.82
Aluminum	Permanent Mold	27	0.7- 2	1.84	0.34	1.15
Aluminum	Semi-perm. mold	7	3.0-67	2.52	1.40	1.89
Aluminum	Die	20	0.26-0.54	5.70	0.64	3.12
Aluminum	Continuous Ingot	5	16 to 24 in. sq.	0.64	0.32	0.49
Magnesium	Sand	15	1.0-49	0.54	0.00	0.28
Magnesium	Permanent Mold	12	0.7-39	1.16	0.27	0.49
Magnesium	Die	10	0.9-2.6	17.40	3.79	5.97

proximating that occurring in the operation of radial aircraft engines, variations in voids of from 0.71 per cent to 2.60 per cent were found to have no significant effect on fatigue life.

It is perhaps not too surprising that this should be so. An effect greater than about 3 per cent reduction in mechanical properties is not to be expected unless some notch or stress concentrating feature accompanies the reduction in section corresponding to the volume of voids. In the application of most castings, it is doubtful whether normal variations in dimensions, design, assembly and other structural features are reproducible within 3 per cent.

Summary and Conclusions

The volume of voids in light alloy castings can be practically determined to within 0.2 per cent by density measurements, providing proper precautions are taken in the determination of the void-free density from the standpoint of segregation, and the relative microstructural conditions of the casting and the void-free density specimen.

A practical method of determining the void-free density is to cast a small standard specimen from the same melt under such conditions that its concentration of voids will be very low. Subsequent working of this specimen, usually at elevated temperatures, will provide a void-free standard with which the density of the casting can be compared.

Variations in density of aluminum alloy sand, permanent mold, and ingot castings are caused principally by variations in general gas or "pinhole" porosity. Usually the shrinkage zones do not constitute a sufficiently large volume to markedly affect density determinations. The voids in commercial sand castings normally vary from 1 to 3 per cent, and in permanent mold castings from 0.3 to 2 per cent.

In magnesium alloy castings, the relatively smaller total concentrations of voids, as indicated by density measurements, is due to the absence of gas porosity. Such variations in density as occur are generally the result of local shrinkage.

The relatively large concentrations of total voids in die castings, both aluminum and magnesium base, are undoubtedly due to the trapped air which is a concomitant of the process.

The effect of gas porosity on the mechanical properties of castings is probably generally not greater than the corresponding reduction in section. In aluminum alloy sand and permanent mold castings, the effect of this reduction in section is usually overshadowed by larger variations in other factors affecting the effective strength of the section.

Although density determination has been demonstrated to be a useful tool in the investigation of light alloy melting and casting technique, it appears to be of doubtful potential utility as a means of general inspection because there has not yet been established any correlation between density variations and engineering or service characteristics.

Reference

1. F. W. Rowe, Bronze Worm-Gear Blanks Produced by Centrifugal Casting," *Journal*, Institute of Metals, vol. 36, p. 191 (1926).

Table 2

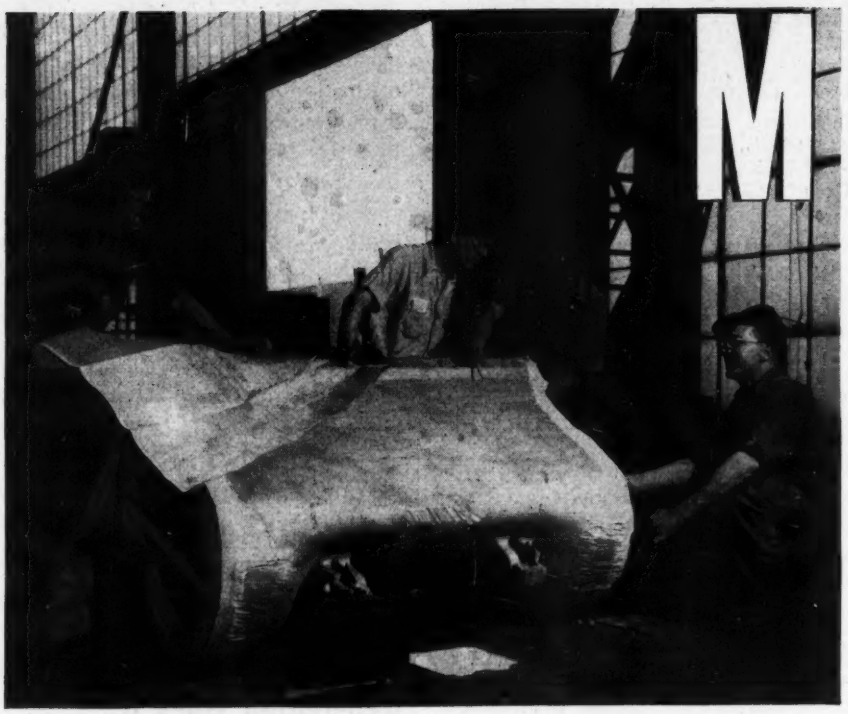
MECHANICAL PROPERTIES OF ½ IN. DIAMETER SAND CAST TEST BARS OF 355-T6 ALLOY CAST FROM MELTS OF VARIOUS GAS CONCENTRATIONS

Gas Concentration	*Voids in Fatigue Specimens, per cent*	*Yield Strength, psi.*	*Tensile Strength, psi.*	*Elongation in 2 in., per cent*	*Brinell Hardness, 500-kg. load, 10-mm. ball*
Low	0.80	29,450	36,350	2.0	90
Medium	1.65	28,740	36,670	2.3	89
High	2.40	29,850	35,800	1.7	88

Kensington Stock Is Acquired by Brokers

KENSINGTON STEEL CO., Chicago, control has been acquired by Poor & Co. who have owned a substantial interest in it for many years. The company will continue under the same management, namely E. C. Bauer, president; Kenneth Jensen, vice-president; R. W. Sergeant, secretary-treasurer; and E. C. Anderson, sales manager.

A coremaker sculptured from foundry molding sand by R. H. Straw, H. C. Macaulay Foundry Co., Berkeley, Calif.



Management, Are You Accepting Your Responsibility?

By M. D. Johnson,*
Quality Manager,
Graham-Paige Motors Corp.,
Willow Run, Mich.

Dimension checking and visual inspection of a steel casting.

IN the writer's opinion, one of the most important contributions the American Foundrymen's Association has made to the foundry industry has been the work done in calling to the attention of the various foundries the need for satisfactory inspection of castings. This phase of the American Foundrymen's Association program has been materially increased in the past year and a half with the appointment of a national casting inspection committee.

Local Committees Urged

It is hoped that as a result of this committee's work, the individual chapters of the American Foundrymen's Association will appoint local casting inspection committees to further investigate the importance of this program. Even though the value of inspection of castings has been raised and brought to the attention of those involved as much as it has, it is surprising to see the great number of foundries that do not have any recognized inspection organization whatsoever. Invariably, the foundries without inspection organizations are those from which are received castings far below what should be considered normal commercial quality.

In the work of the Inspection of Castings Committee attention is often called to the value of such inspection processes as x-ray, gamma ray, and magnetic particle inspection, but the factor that should concern most foundries is the value of just straight visual inspection.

It is not the intent to imply that these more critical types of inspection are not necessary. However, there is no need of worrying about such types of inspection as long as castings are shipped from foundries to ultimate users with cracks and blow holes so large that they not only can be seen plainly with the naked eye but many times are of such size that one can insert a fingernail or whole finger in the obvious defect. For some reason or other it has been difficult to bring this serious condition to the attention of the greater part of foundry managements.

Two Factors

We cannot help but feel that the shipping of such obviously defective castings is caused by two factors. First, in the foundry that does not have an inspection organization, invariably that foundry management depends on normal segregation of defective castings by both the cleaning room and the shipping room supervision and workman. It is natural that in these trying times ultimate users emphasize the need of a certain quantity of castings. It is just as natural that the cleaning room and shipping supervision will have as their main objective the shipment of the quantity of castings rather than to ship lesser quantities with the defective castings thrown out. Second, too often foundries talk in terms of the percentage of yield, but they look on this yield as the tonnage actually shipped from the foundry rather than the ultimate yield which would take from this the tonnage of castings rejected by the final users.

Many Users Served

There is no question but that all foundries serve many users, and these users of the castings have different standards of quality. However, if every foundry would institute an inspection program and discard the obviously defective castings which are of absolutely no value in any commodity, and then develop a more rigid method of inspection for the more critical users, then foundries, in general, would materially improve their standing in the industry.

We can think of no better way of concluding this article than asking you of Foundry Management if you are one who is willing to allow obviously defective castings to be shipped from your plant.

*Formerly Chief Inspector, Caterpillar Tractor Co., Peoria, Ill. Member and former Chairman, Inspection of Castings Committee, A.F.A.

• The relation of amount of metal frozen to time cannot be satisfactorily explained if the conductivity of molding sand is taken as independent of temperature. It is shown that a better correlation can be obtained if the heat transfer within the sand is assumed to be in part by conduction and in part by radiation.

The Influence of Radiation Within Molding Sand on the **FREEZING RATE** *of Metal*

By H. A. Schwartz, Manager of Research,
National Malleable & Steel Castings Co., Cleveland.

IT HAS been shown by the writer[1] that there is good agreement among reliable workers that for some time during the freezing process the thickness of the frozen layer of steel increases as the square root of the time, but later increases in proportion to the time. That is to say, the time-thickness curve is first a parabola and then a straight line tangent thereto.

This type of curve is qualitatively alike for many shapes and sizes of castings and always represents a rate of freezing faster than can be calculated from the usually accepted thermal conductivity of sand. Nor can the form of the curve, representing an acceleration of the freezing mechanism, be explained by any plausible assumptions.

To throw some light on this subject, the author here offers an admittedly inaccurate solution of a problem not realized in the foundry under hypothetical conditions resting on no direct evidence. He can only justify such rashness by saying that the mathematicians seem unable to furnish an accurate solution. The problem is one which is closely approached during the early stages of freezing of flat-sided objects, and apparently the conditions are maintained for a considerable time in even moderate-sized castings. The problem is, therefore, reasonably simple of attack and a reasonable approach to reality.

It is the purpose of the paper to determine whether the hypothetical conditions are reasonably consistent with the known facts. Be it noted, however, that if they are so consistent this is not proof that they *are* the cause of the observed effects but only that they *may be* the cause. Perhaps other causes could explain the effects, also. Radiation is probably a sufficient explanation of what happens, but not a necessary explanation.

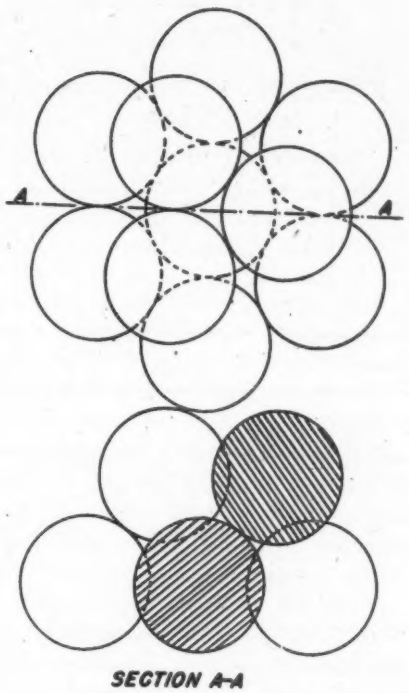
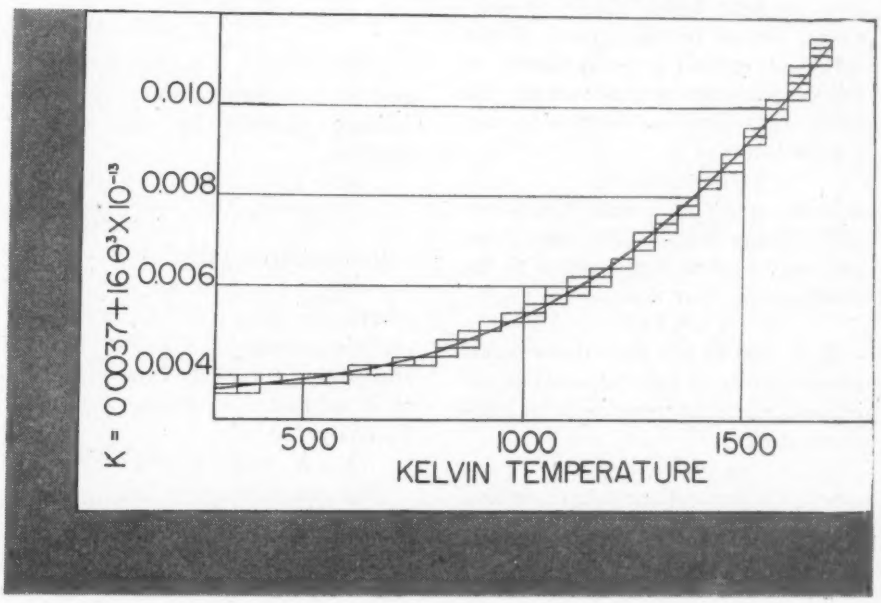


Fig. 1—Above—Close packed arrangement of spheres. Fig. 2—Below—Apparent thermal conductivity of sand as a function of absolute temperature.



We desire to find what is the form of the curve correlating the amount of heat absorbed as a function of time by a semi-infinite body of sand whose surface is suddenly heated by 1400° C. (2520° F.) above an initial uniform temperature of 27° C. (80° F.=300° K.) if the properties of the sand are as follows:

The apparent density (ρ) of the sand as packed is 1.65 gm./cm.^{3}, and the apparent specific heat *(C)* is 0.45 cal./gm., both independent of temperature. The sand consists of uniform spheres one mm. in diam-

This paper was secured as part of the 1945 "Year-'Round Foundry Congress" and is sponsored by the Committee on Heat Transfer of A.F.A.

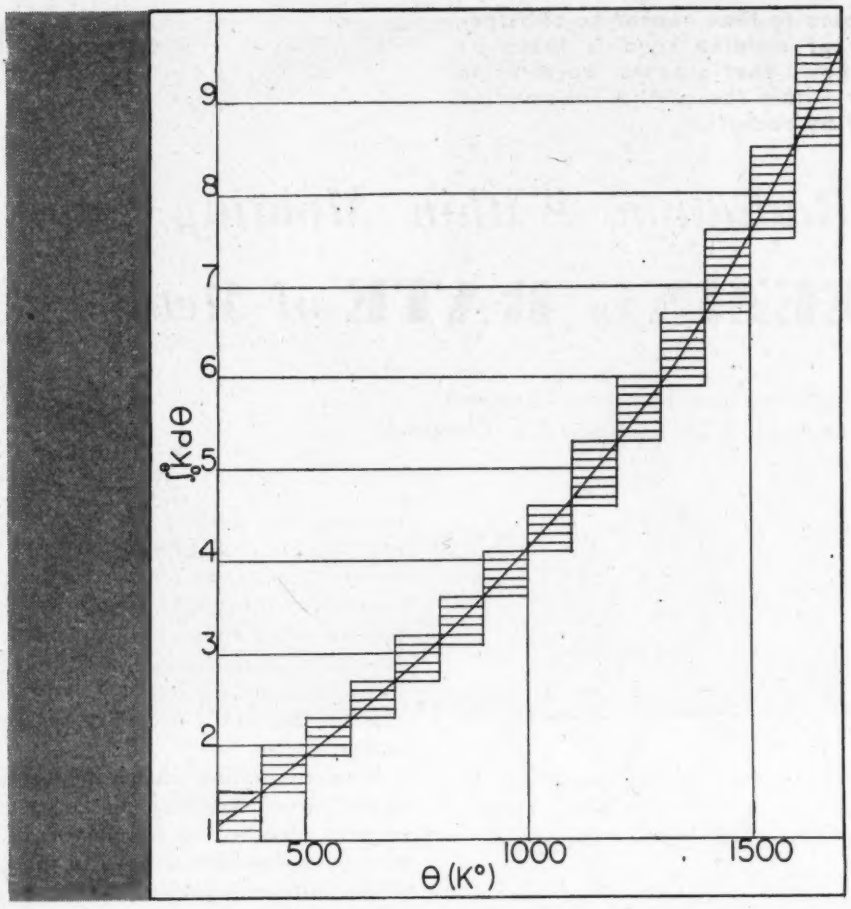
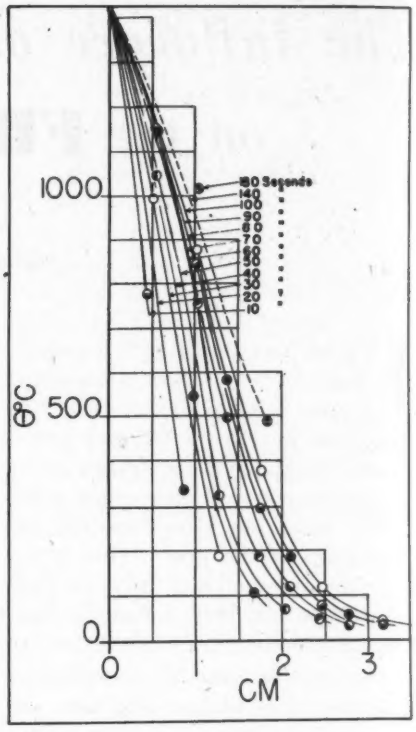


Fig. 3—Left — Chart for determining the mean thermal conductivity of sand.

Fig. 4 — Below — Temperature within the semi-infinite sand body as a function of time and distance.



eter "close packed" in layers at right angles to the direction of heat flow. The apparent conductivity *(k)* at 300° K. is 0.0037 cal. cm.$^{-1}$ sec.$^{-1}$ °C.$^{-1}$ and the sand grains radiate as "black bodies," the highest radiation which can exist. The latter condition is chosen to evaluate the maximum effect.

The postulated arrangement of sand grains is shown in Fig. 1, the flow of heat being taken as horizontal. If R be the radius of the spherical grains, it is a matter of simple geometry to find that the distance *(D)* between centers of successive layers is

$$D=1.632\ R,$$

and the area *(a)* of sand grains surface, facing toward the next layer per unit area at right angles to the direction of heat flow, is

$$a=3.63.$$

If θ_1 and θ_2 are then the absolute temperatures of two adjacent layers of sand, the heat transferred by radiation alone is

$$a\sigma\ (\theta_1^4 - \theta_2^4),$$

where σ is the radiation constant and equal to

5.7×10^{-5} erg cm.$^{-2}$ sec.$^{-1}$ °C.$^{-4}$.

Converting from ergs to calories and substituting for a its value, the heat (cal.) radiated per sec. per sq. cm. of area at right angles to the direction of heat transfers becomes:

$$a\sigma\ (\theta_1^4-\theta_2^4)=$$
$$49.368\ (\theta_1^4-\theta_2)^4\times10^{-13}.$$

If k_0 be the true conductivity of the material assumed independent of temperature, then the total heat transferred in one sec. per unit area of cross section

$$\frac{(\theta_1-\theta_2)\ K_0}{D}+$$
$$49.368\ (\theta_1^4-\theta_2)^4\times10^{-13},$$

and the apparent conductivity is this amount divided by the thermal gradient

$$\frac{\theta_1-\theta_2}{D}=\frac{\theta_1-\theta_2}{1.632R}.$$

Remembering that $(\theta_1^4-\theta_2^4)=(\theta_1-\theta_2)\ (\theta_1+\theta_2)\ (\theta_1^2+\theta_2^2)$ and making the reasonably accurate simplifying assumption that $\theta_1=\theta_2=\theta$, and setting for D its value in terms of R, we find that the apparent conductivity *(k)* is

$$K=K_0+324\ R\ \theta^3\times10^{-13}.$$

The conductivity is thus a function of the sand's grain size. For grains having a diameter of one mm., and assuming that at 300° K. the conductivity is 0.0037, we may write approximately

$$K=0.0037+16\ \theta^3\times10^{-13}.$$

The values of K as a function of absolute temperature (θ) are plotted in Fig. 2. In Fig. 3 the area under the curve of Fig. 2 is plotted against θ. The difference between the ordinates of this curve at two temperatures, θ_1 and θ_2 when divided by $\theta_1-\theta_2$ gives the mean value of K in that temperature range.

The general differential equation for the (linear) flow of heat is:

$$\frac{\delta\theta}{\delta t}=h^2\frac{\delta^2\theta}{\delta x^2}$$

where t is time (sec.) and x is distance (cm.).

The solution of this equation for the boundary conditions enumerated in the statement of the problems would be simple if h^2 were constant, but $h^2=\frac{k}{\rho c}$ by definition and, therefore, varies with the temperature. The solution of

$$\frac{\delta\theta}{dt}=\frac{0.0037+16\ \theta^3\times10^{-13}}{0.7425}\cdot\frac{\delta^2\theta}{\delta x^2}$$

has been impossible for the writer, and also for those consulted who were more skilled in mathematics.

We, therefore, turn to the graphi-

cal Schmidt method as the only recourse. The method has been briefly described by the author in the 1945 Foundation Lecture. For a detailed description consult Sherwood and Reed[2].

The Schmidt method assumes that if time and distance are divided into increments Δt and Δx such that

$$h^2\frac{\Delta t}{(\Delta x)^2}=\tfrac{1}{2}$$

then at a given time a given point will have a temperature equal to the average temperature of the two points Δx on each side of it (in the direction of heat flow) taken Δt previously. The Schmidt solution is a graphic method of plotting, as a function of temperatures at a series of times differing by Δx.

Since $h_2=\frac{K}{\rho c}$, this is equivalent to saying for sand ($\rho=1.65$ $C=0.45$) that

$$\Delta x = 1.842\sqrt{K}\sqrt{\Delta t}.$$

The time increment is subject to arbitrary choice; 10 sec. was selected for the solution. The conductivity K depends on the temperature and can be approximated rather closely from the conditions Δt earlier. It is thus possible to calculate the value of Δx, appropriate to any time and position. For convenience, the sand, the temperature of which is really a continuous function of x, is assumed to consist of layers 0.5 cm. thick; the temperature of each layer being considered uniform.

The actual graphic solution is too voluminous to be repeated here, but the temperatures at a series of times are plotted against distance below the sand surface in Fig. 4. For convenience, the temperatures have been converted from the Kelvin to the Centigrade scale.

The rate of heat input, per unit area,

$$\frac{dH}{dt} \text{ is } \frac{dH}{dt}=K\frac{d\theta}{dx},$$

where K is the conductivity at the surface which, by assumption, is at 1700° K. or 1427° C. K, therefore, is constant, with time, and from Fig. 2 is equal to 0.0116. $\frac{\Delta\theta}{dx}$ is the slope of the lines of Fig. 4 at $x=_0$ and, of course, varies with the time.

Lines Graphically Determined

The lines of the figures are not reproduced with sufficient accuracy to permit of reading their slopes, but these have been graphically determined from the originals and plotted as points in Fig. 5. The evident scatter is in part due to the inherent difficulties of graphic estimation of the slope of a curving line. A line has been drawn by inspection to show the trend of

$$\frac{dH}{dt}$$

as a function of t. A line has also been drawn showing this relation for the room temperature conductivity of sand. Evidently there is a great discrepancy.

Most notably the present assumptions lead to a locus which seems to reach a constant value of

$$\frac{dH}{dt},$$

while the assumption of a constant conductivity results in a curve which continues to descend, at a decreasing rate, to zero. We can not, of course, be too sure what the observed trend line would do if indefinitely prolonged.

The line marked $K=0.0070$ is the best fit for our complex locus, assuming a constant "apparent" conductivity, and does not fit the observations at all. We can not, therefore, approximate the effect of changing conductivity by the use of some average value. Quite empirically the locus put in by inspection conforms with no important discrepancies to

$$\frac{dH}{dt}=\frac{94.2}{\sqrt{\pi t}}+0.000036\ (60-t)^3 \quad \left(\text{for } \frac{\Delta H}{dt}>6.0\right).$$

The term $\frac{94.2}{\sqrt{\pi t}}$ represents the calculated value of $\frac{dH}{dt}$ if $K=0.0061$. The right half of the equation could

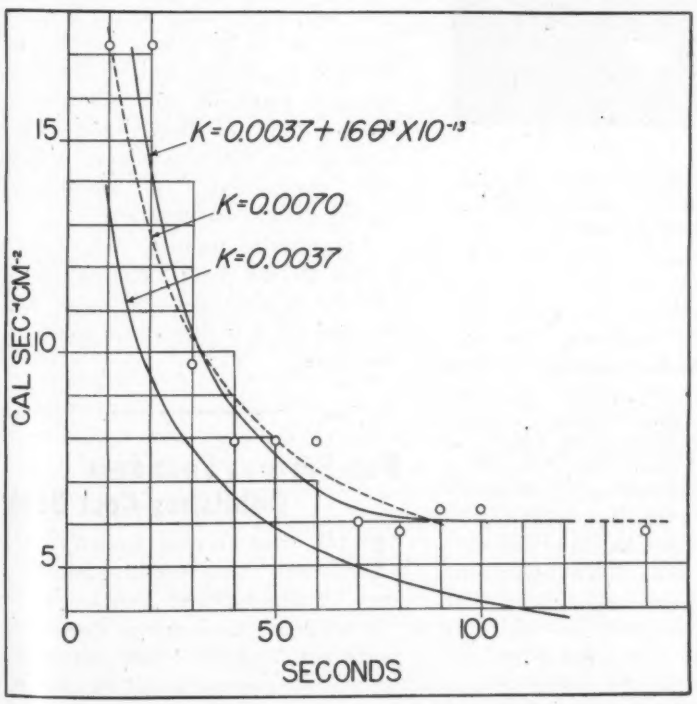


Fig. 5—Rate of heat input into a semi-infinite sand body as a function of time.

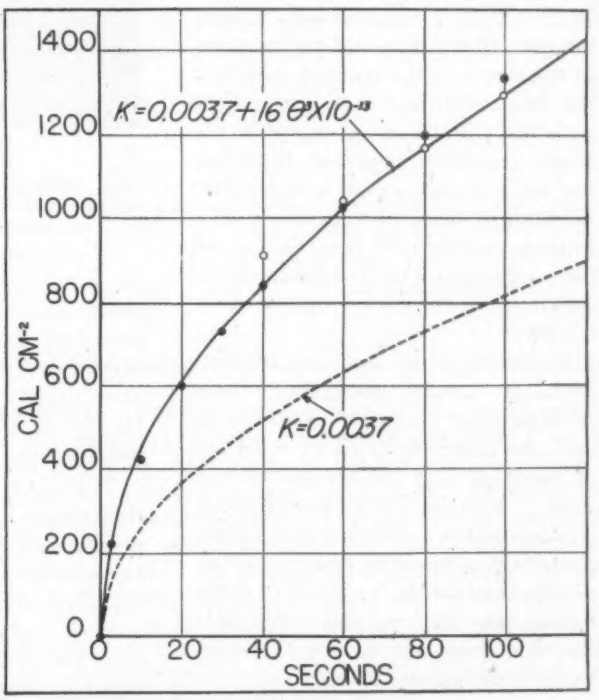


Fig. 6—Heat absorbed by semi-infinite sand body as a function of time.

be recast as a multiple of $\frac{1}{\sqrt{\pi t}}$ and, from the value of that multiple and the known ρ and c, the "apparent" value of K as a function of t derived, but this would yield no information not contained in the above empirical equation, for the "apparent" value of K would only be another empirical means of expressing the same thing.

Computation of Heat Absorbed as Function of Time

Evidently the heat absorbed in time t by the sand will be

$$H = \int_0^t \left[\frac{94.2}{\sqrt{\pi t}} + 0.000036\ (60 - t)^3\right] dt$$
$$= 106.4t^{\frac{1}{2}} - 9\ (60-t)^4 \times 10^{-6} + 125.6$$

provided $\frac{dH}{dt} > 6$.

Thereafter $\frac{dH}{dt} = 6$ and $\Delta H = 6\Delta t$. One refrains from solving the expression for $\frac{dH}{dt}$ for t if $\frac{dH}{dt}$ be 6 as a laborious piece of pedantry and lets the graphic solution suffice.

In Fig. 6, H is plotted in terms of t as derived from the foregoing equations.

For comparisons the values of H corresponding to the conventional value 0.0037 for K are plotted as a dotted line. The dots of Fig. 6 fall on a parabola ($t = 0.000057H^2$ approximately) and the circles are a straight line. Note first that the curve computed from $K = 0.0037 + 16\ \theta^3 \times 10^{-13}$ passes through a combination of the dots and circles within the errors of the method, and that the heat absorbed in a given time with the variable K is, except at the origin, considerably greater than that for the constant room temperature K. Both of these observations qualitatively confirm the observations on bled castings. The parabola corresponds to a constant value of $K = 0.0098$.

It seems that our calculations probably predict somewhat faster freezing than is usually experienced, and also place the point of tangency of parabola and line at too early a time. Both of these discrepancies could arise from overemphasis on the contribution made by radiation. Purposely, the highest reasonable contribution was chosen, and very likely the sand grain size and/or the emissivity were overestimated.

Conclusions

It seems that the published data on rate of freezing of castings agree better with the assumption that the conductivity of sand varies with its temperature than with any constant conductivity.

They agree, in form, with the type of relation of conductivity which would result if the relation of apparent conductivity and temperature is that which would result if radiation within the sand body determined this relation.

The transfer of heat by radiation is probably quantitatively somewhat less than that assumed in this paper.

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1. H. A. Schwartz, "How Fast Do Metals Freeze?" *The Foundry*, Dec., 1944, p. 80.
2. Sherwood and Reed, *Applied Mathematics in Chemical Engineering*, McGraw-Hill, New York, 1939, p. 241.

ELECTRO-ALLOYS

Puts Postwar Expansion Into Effect

GROUND was broken recently for a $2,500,000 construction program at The Electro-Alloys Company foundry at Elyria, Ohio. Grinder Tony Whitman, who has the longest service record at the plant, and William B. Given, Jr., president, American Brake Shoe Co., turned over the first spadefuls. This new project will include a completely new alloy foundry, office building and employees' building.

Tony Whitman, Electro-Alloys employee, shoves spade into the ground where new foundry will be erected.

"The new foundry will be more than four times the size of the present one," said W. G. Hoffman, president, Electro-Alloys Division. Capacity operation will call for 300 workers, as compared to the 100 now employed. Expansion of the plant is part of American Brake Shoe Company's postwar program, and one of the first to be put into effect is the expansion of the Electro-Alloys plant at Elyria.

Equipment for the new foundry is to include three induction and three electric arc melting furnaces, sand conditioning and sand handling equipment, 15 molding machines, mold and core ovens, sandslinger, heat treating furnaces, and an installation of centrifugal casting machines. New X-ray equipment will be added to that already installed, as it is a basic policy that all castings are X-ray controlled. Sand testing, chemical and physical laboratories will be located in the foundry.

A new office building, 100 ft. x 50 ft. will be erected, and will provide ample working space for the employees. A two-story Employees' Building is another unit in the construction program, and will contain lunch room and shower and locker facilities for 300 employees. A new boiler room makes the fourth unit in this expansion program.

The existing foundry will be converted to the new cleaning room, and the present cleaning room, will be used for a maintenance and pattern shop.

Non-Ferrous Founders Publishes Cost Book

THE Non-Ferrous Founders' Society has recently issued a very comprehensive booklet on "Simplified Accounting Procedure and Cost Methods." The chairman of the committee is L. M. Nesselbush, Falcon Bronze Co., Youngstown, Ohio.

MALLEABLE SAND CONTROL in a Large Mechanized Foundry

By Joseph J. Clark, Assistant Metallurgist,
Saginaw Malleable Iron Division, General Motors Corp.,
Saginaw, Mich.

USE of synthetic sand has become widespread with the advent of the high production foundry. The economic aspects and the control features have made it virtually a necessity in this type of shop.

Certain foundries employ two synthetic sands, one for facing and one for backing purposes. The backing sand is ordinarily supplied by suitable conveyor to hoppers over the molding stations, while the small quantities of facing are supplied by wheelbarrow to a box at the station, or by separate conveyor and hoppers.

While the requirements of some castings are such that two sands are needed, it is obviously highly advantageous, from a production and cost standpoint, to use a single, or 100 per cent facing sand. When using one all-purpose sand, it is equally obvious that more extensive conditioning equipment and more rigid control of both the molding sand and cores are required. As to raw materials involved, it is necessary that dependable sources be established for obtaining uniform raw sand, clay, seacoal, flour, core oil.

It is the purpose of this paper to describe the raw materials, equipment and controls employed in the synthetic, all-facing sand systems of a modern, high production malleable iron foundry, producing medium finish automotive and gun part castings, the weights ranging from a few ounces to 65 lb.

Raw Material Storage

Figure 1 shows the layout of the raw material storage building, containing bins for raw and prepared sand, clay and coal. A 5-ton traveling crane spans the building and railway siding to permit transfer of these materials by clam bucket. One portion of the storage building, directly below the small storage hoppers, is devoted to core sand mixing and seacoal preparation.

Attached to the main storage building is a sheet metal structure which houses the two sand driers and provides storage space for bagged materials such as flour, red iron oxide, clay, etc., used in core mixtures. Next to the drier building are the core oil storage tanks from which core oil is pumped to the core sand mixing room as it is used. All coal, clay, flour and core oil are purchased in carload lots.

The sand used in cores, and which ultimately becomes foundry molding sand, is a bank sand obtained from pits within a few miles of the foundry. It is hauled to the plant daily by truck and dumped into a concrete pit in one end of the sand storage building. From here it is transferred either to the wet sand storage bin or directly to the wet sand hoppers which feed the sand driers. The major portion of the sand stored for use is dried sand.

Sand Drying. Raw sand from the pits varies in moisture content from 3 to 9 per cent. It is the purpose of the sand driers to reduce this moisture to a very low and constant level (0.2 per cent approximately) so that moisture control of core sand mixtures can be maintained.

Each of the two parallel-counterflow type driers is capable of drying and cooling 8 tons of sand per hour. This figure is based on 7 per cent moisture in the incoming sand. A diagram of one of the driers is shown in Fig. 2. Due to the design, the driers are very efficient. A firebox located at the front end of the drier supplies heat to the air which is blown through and around it into the heating tube, as indicated by the arrows.

The firebox is fired with natural gas and is automatically maintained at 1400° F. Wet sand is fed into the rotating drum between the outer shell and the heating tube. Blades attached to the inside surface of the outer drum, alternately raise and drop the sand as it works toward the midsection of the drum, thus exposing it to the heated stream of air.

The path of the air stream is such that the temperature of moisture laden gases leaving the stack in the heating section is less than 212° F. At the midpoint of the drier, the moisture in the sand has been reduced to about 1.5 per cent. The sand enters the cooling section of the drier through special inclined feed scoops, which also act as a baffle between the heating and cooling sections.

As the sand enters the cooling section, it falls on a fixed thermocouple. The temperature of the sand at this point is used to control the final exit temperature of the sand and subsequent moisture con-

• This paper on malleable foundry sand control is one of several being prepared at the request of the Malleable Division Program Committee, which is planning to continue the yearly symposia on malleable foundry practice started several years ago. These papers on this subject will later be incorporated in a reprint on malleable sand control as the Division's contribution to the 1945 program. Included in this symposium will be the summary of some 14 companies' answers to a questionnaire on malleable sand control.

The ultimate objective of the Division is to later incorporate all of these symposia in a book on malleable foundry practice. Previous symposia covered (1) Graphitization of White Cast Iron, (2) Malleable Iron Melting, and (3) Gating and Heading.

tent. This is accomplished by a pyrometer-controlled damper on the fan supplying air to the heating section of the drier.

Decreasing sand temperature automatically increases the amount of hot air blown through the heating section, and vice versa. A constant volume of air is blown through the inner cooling tube by a separate fan. The velocity of the cooling air is such that considerable "pan" material or fines are removed from the sand and are carried out the exhaust into a dust collector.

The sand is discharged from the cooler at temperatures between 95° and 110° F. into an elevator, which in turn drops it onto a 20-mesh vibrating screen inclined at a 33° angle. Extraneous materials, coarse sand, roots, etc., pass over the screen and are collected in a tailings hopper. The dried sand passing through the screens is carried by conveyor belt to the dry sand storage bins.

Seacoal Preparation. Seacoal for use in the sand units is prepared by crushing coal purchased exclusively for this purpose. The seacoal crusher is one of the latest types, employing the ball bearing grinding principle with spring loading of the grinding elements. It operates at relatively low speeds. The unit will supply 3000 lb. of seacoal per hour.

Core Sand Preparation. The core sand mixing and handling equipment is shown diagrammatically in Fig. 3. The mixers are of the kneading type, having Sigma-shaped blades. Standard batches mixed in them are made up for either 1800 lb. or 1050 lb. of sand.

All dry ingredients are weighed, and all wet ingredients are measured by volume. Dried sand from any one of several overhead hoppers may be discharged into a weigh lorry by means of electric vibrating feeders. The feeder is automatically stopped by an electric eye device on the scale when the batch weight of sand is in the lorry. The lorry may then be moved along the overhead rail and the sand discharged through a butterfly valve into any one of the mixers.

Corn flour, which has been weighed, is added to the mixer as the dry sand is flowing into it. Any other dry ingredients such as red oxide, clay, etc., also are added to this time. These are dry mixed for one min., followed by addition of the water and core oil in that order.

The batch is wet mixed for 7 min., making a total mixing time of 8 min. A time clock is used to notify the operator when mixing time is up. The prepared sand is then discharged onto a conveyor belt below floor level, and from here it is elevated and discharged into one of a cluster of hoppers conveniently arranged in the core room.

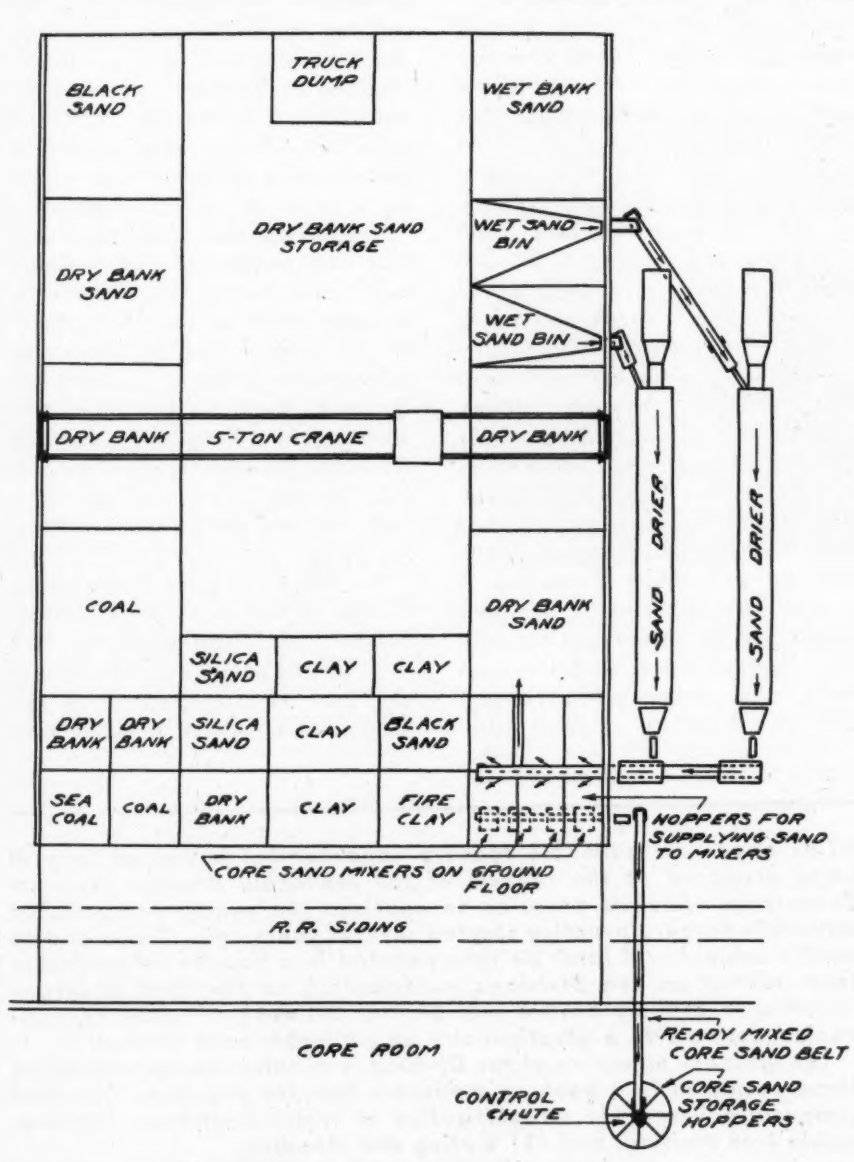


Fig. 1—Layout of sand storage and preparation units.

Core Mixture Control

Since there are a number of different core mixtures in use at all times, it is important that each type goes into the proper hopper. This has been cared for by means of an electrically controlled receiving chute (Fig. 1) above the cluster of storage hoppers which are arranged in a circle in the core room. By means of push buttons and signal lights, the operator in the mixing room may revolve the chute about its axis to a position over the proper hopper and then proceed to dump the mixer.

Foundry Molding Sand Handling and Conditioning Units. Four individual sand units are used, each one equipped to completely handle and condition its own sand. Every unit must furnish a continuous supply of sand to the various molding stations of the production lines composing the system. There are no batch type operations in any of the systems.

The number of molding stations supplied by a sand unit varies from 10 to 34, depending upon the type and size of molds made on the lines. Since different standards of moisture, permeability, etc., are maintained on each system, the placement

of patterns in the most suitable unit is possible. Figure 4 shows a schematic diagram of one of the units.

Prepared sand is plowed off the overhead, or "flight" belt conveyor into the individual sand hoppers located above each molding machine. The quantity of sand sent out on the belt and the adjustment of the various plows is gauged by an operator who patrols this section of the sand system.

An improvement in discharge of sand from the molder's hopper to the flask has been made by installing an electric vibrating feeder on each hopper, instead of the usual manually operated jaws. Much better control of the amount of sand for each flash is obtained, thus reducing the spillage of prepared sand. Labor expended in operating the jaws is eliminated.

Automatic Equipment

An automatic jolt-squeeze equipment is provided for each molding machine. The operator's controls consist of a "jolt" push button, a "squeeze" push button, and a "stop" button. The jolt button engages a timer which gives the mold a predetermined number of jolts, whereas the squeeze button actuates controls governing the intensity and duration of the squeeze and, in addition, it controls the slow draw of the pattern from the mold.

Any excess or "spill" sand from the mold falls through the floor grating which surrounds each molding machine and drops onto a spill-sand conveyor belt in the pit below. Excess sand from the end of the overhead flight conveyor also drops onto this belt through a tail chute. Spill

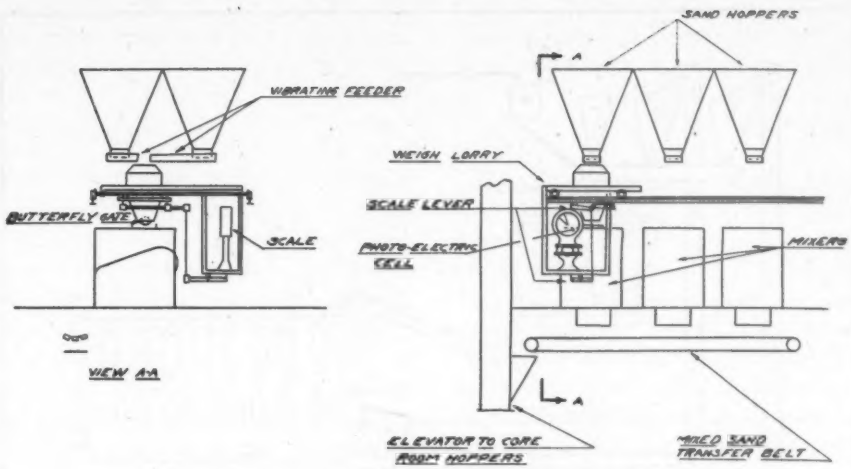


Fig. 3—Views of core sand weighing and mixing equipment.

sand collected in this manner is returned to the spill sand storage bin after passing over a magnetic pulley and through a vibrating screen.

Completed molds are placed on a conveyor which carries them past the pouring conveyor, where they are poured off. The poured molds continue through a cooling hood and finally reach a vibrating shakeout screen, where the castings are shaken out of the molds. The shakeouts are of rugged construction and the motion is sufficiently violent to remove all but a very small amount of sand from the castings.

Handling Shakeout Sand

Shakeout sand passing through the shakeout screen falls into an electric vibrating conveyor in the pit, and is fed into a horizontal cylindrical cooling drum. As the cooling drum rotates, the sand is picked up by a series of blades attached to the inner wall. Air is drawn through the drum, cooling and drying the sand as it falls from the blades. The velocity of the air is such that a considerable amount of fines is removed from the sand.

From the cooling drum, the shakeout sand passes over a magnetic pulley, is screened to remove core butts, lumps, etc., and falls into the shakeout sand storage bin.

Floor hoppers with controlled feeders are provided so that, if desired, sand may be added uniformly to either the shakeout sand or the spill sand.

The shakeout sand storage bin, the spill sand storage bin, and the seacoal bin are located in a row for convenience in feeding the continuous muller. The shakeout and spill-sand bins are equipped with electric vibrating feeders, while the seacoal bin has a variable speed screw feeder. Controlled amounts of each of these materials are fed onto a cross-belt which spills into the entrance of the muller, where clay and water in slurry form are added.

The slurry is prepared in a special tank overhead, and feeds down by gravity through a pipe to the muller. A simple plug type hand valve is used to regulate the rate of flow of the slurry to the muller. In the preparation of the slurry, clay and water are fed into a tank where two propeller type agitators rapidly establish and maintain the suspension of the clay in the water.

The size and shape of the tank and the positioning of the agitators are of prime importance in making an effective slurry. In order to maintain the slurry level in the tank, a float switch is used to stop or start the flow of water and clay simultaneously. In the case of the water, the

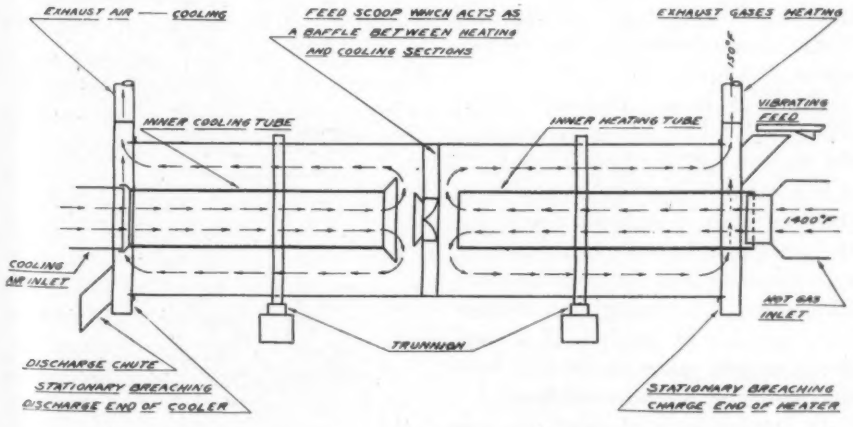
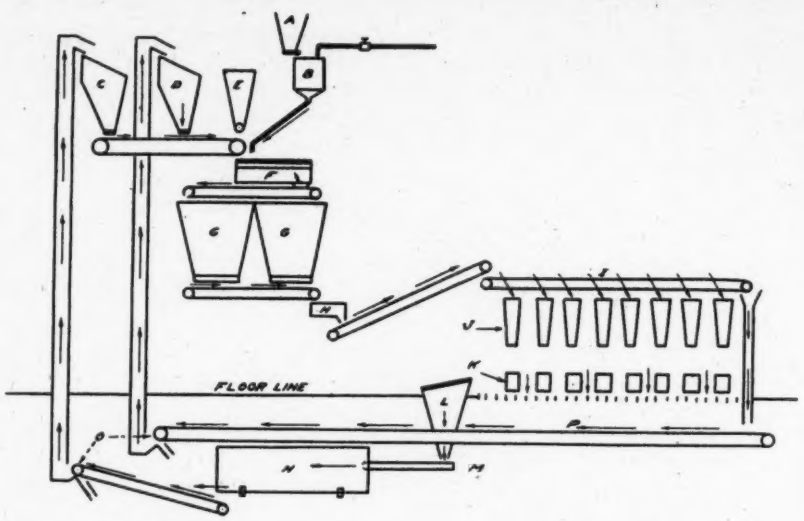


Fig. 2—Diagram of combination parallel and counterflow sand dryer and cooler.



A. Clay hopper
B. Slurry preparation tank
C. Shakeout sand bin
D. Spill sand bin
E. Seacoal bin
F. Continuous muller
G. Tempering bin
H. Revivifier
I. Flight belt
J. Molder's hoppers
K. Molding machines
L. Shakeout
M. Vibrating conveyor
N. Cooling drum
O. Magnetic pulleys
P. Spill sand return belt

Fig. 4—Schematic diagram of foundry molding sand handling and conditioning unit.

float switch operates an on-off solenoid valve in the water line; in the case of the clay, it stops or starts the variable speed screw feeder, located at the base of the clay bin.

A pressure regulator controls the water-line pressure so that a uniform rate of discharge of water into the slurry tank is maintained during the time the solenoid valve is on. The rate of clay feed may be adjusted by changing the speed of the screw feeder.

The mixture of spill sand, shakeout sand, seacoal, and slurry enters the muller from the crossbelt and is mulled as it progresses to the opposite end, where it is discharged through an opening in the base. Figure 5 shows plans and sectional sketches of the muller which is equipped with Sigma-shaped blades attached in segment form to two horizontal shafts.

The shafts rotate in opposite directions and at different speeds, the blades working the sand inward against the "saddle." In order to mull effectively, the proper clearance between the blades and muller faces must be maintained. This is made possible by the use of renewable white iron shoes bolted to the blades. A 125-horsepower motor drives the muller.

The mulled sand drops onto a conveyor belt from which it may be plowed off into either of two 150-ton tempering bins. These bins are of sufficient size to permit sand to temper for at least one-half hour. For control purposes, sand is fed from one bin for 30 min., then from the other. Each bin is equipped at the bottom with an electric vibrating feeder which shakes a regulated amount of sand onto the cross belt below it.

As the sand leaves the tempering bin, it receives a final conditioning in a revivifier, where the action of a revolving "squirrel cage" aerates the sand as it passes through. From here it travels to the flight conveyor to service the molding stations. Approximately 175 tons of sand per hour are "turned over" on this unit. Total sand carried in the unit is about 250 tons.

Raw Material Control — Bank Sand. The raw sand is a sub-angular bank hand of approximately 70 A.F.A. grain size. It is important that no major deviations develop in the grain distribution. Consequently, a routine check of the grain distribution curve of incoming sand is made once per day by analysis of a composite sample taken at the belt feeding raw sand to the sand driers.

In making an analysis of the sand by means of distribution curves, extra sieves, other than standard, often furnish more detailed information. They are used regularly. Figure 6 shows bank sand curves plotted with standard sieves, and with the additional sieves.

The control of the exit temperature (95 to 110° F.) of the sand from the driers is of utmost importance. Hot sand is to be avoided for two good reasons:

1. Loss of moisture control of core sand mixtures due to evaporation.
2. Hot sand in core mixtures causes sand to stick in core boxes.

Sand under 95° F. at the drier discharge is also to be avoided because it will be too wet.

In addition to drying the sand, two other controls of bank sand incorporated in the driers and auxiliary equipment are:

1. Removal of fines in the cooler section of the driers.
2. Removal of very coarse sand and extraneous material on the vibrating screens.

Screen analysis of the tailings is used as a check on the efficiency of the screening operation.

From time to time new pits must be opened. At such time, the sand supervisor goes to the pit to observe the general conditions and sampling procedure to assure himself that samples to be tested are representa-

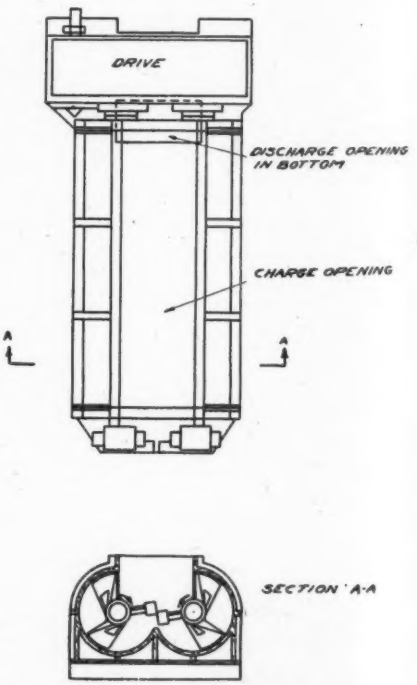


Fig. 5—Plan and sectional sketches of continuous sand muller.

tive of the average sand to be taken from the pit.

Clay. The clay used is an unpulverized (30 mesh) rebonding type clay of high refractoriness and good durability. A check on the latter quality is always available through accurate records of the tons of metal poured versus clay consumption on the sand units. Incoming cars of clay are checked for green and dry bond according to A.F.A. standard procedure.

Seacoal. Coal for manufacturing seacoal is of a West Virginia variety, purchased under the classification of 1¼-in. nut, pea, and slack. Cars are sampled as received, and laboratory tests are made for ash, volatile combustible matter, and fixed carbon. A minimum of 30 per cent volatile combustible matter, and a maximum of 6 per cent ash are specified.

The seacoal is crushed to a fineness such that 99 per cent will pass through 100-mesh and 85 per cent through 200-mesh screens. Periodic screen analyses are made to insure that the foregoing specification is maintained because experience on the sand systems has shown that many detrimental effects result from the use of too coarse a seacoal. These may be enumerated as:

1. Blows become much more prevalent in castings, particularly the smaller ones.
2. Casting finish is poorer.
3. Greater quantities of seacoal are required because of ineffectiveness of it.
4. The molding sand accumulates more coke and ash, which reduces tensile strength of the sand, ultimately resulting in molding difficulties.

Core Oil. Each car of core oil is subjected to test by both the chemical and sand laboratories.

Specific gravity, saponification number, and viscosity are reported on each car by the chemical laboratory.

Two sets of tests are conducted by the sand laboratory. One of these consists of baked tensile and permeability tests made on specimens taken from a laboratory mixture, using standard sand, and baked in the laboratory oven. The other is identical, except that the baking is done in production ovens.

A particular core oil may show excellent properties in a core baked in the laboratory oven for 1½ hr. at 420° F.; however, it is often the case that, due to the inherent characteristics of the oil, the same core may show much poorer when it is subjected to the baking cycles used on the production ovens. The latter test often classes an oil as unsuitable for use in the core room without making major changes in coreroom practice.

Flour. New batches of flour are checked for green compression strength, using an emperical mixture with standard sand. Since a major portion of the cores are blown, the characteristics of the flour which effect its "blowability" for intricate core sections are under as close observation as are other properties. To aid in the selection of flours with suitable blowing properties, and as a routine check on incoming shipments, the weight per cu. ft. is determined according to an arbitrary standard.

This check is made by sifting the flour through an ordinary sifter placed on a fixed funnel which sets on a quart measure. The funnel diameter is almost as large as the quart measure. When the quart measure is filled to overflowing, the excess is scraped off with a straight edge. The weight of the quart of flour is obtained in grams and converted to lb. per cu. ft.

It has been the experience that the lighter flours (10 to 13 lb. per cu. ft.) "blow" much better than the heavier flours (14 to 20 lb. per cu. ft.). On this basis a maximum of 13 lb. per cu. ft. has been set up

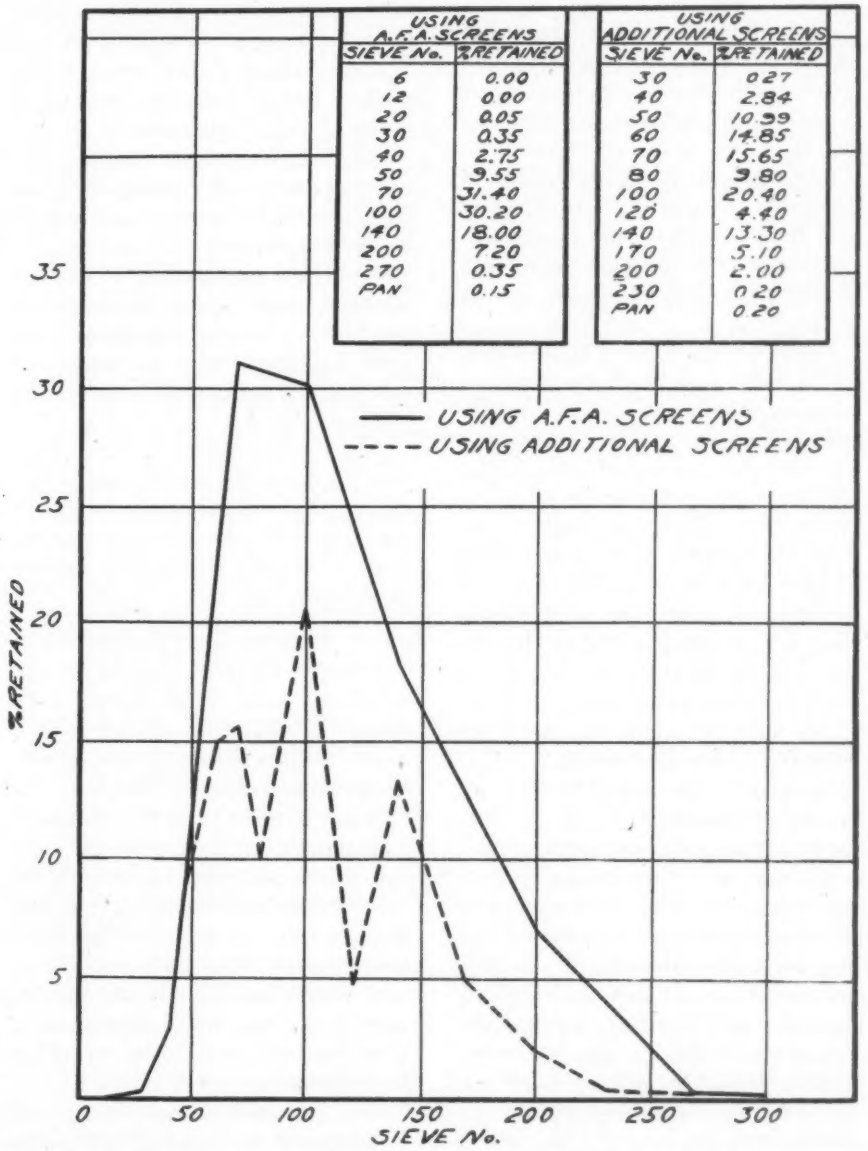


Fig. 6—Bank sand distribution curves plotted with standard and additional sieves.

as an arbitrary figure for the density of flour.

The variations in flour from shipment to shipment can cause no end of trouble in the coreroom if precautions are not taken in segregating the shipments. Moreover, if flour stands for long periods of time, the green bond developed by it is lower. A system has therefore been established wherein the oldest flour is used first; incoming batches are piled in rotation. Flour adjustments in the core mixtures may then be made as needed and consistent results obtained.

Core Sand Control. In a synthetic sand system, sand additions to the system should come entirely from the cores. Consequently, the core practice with respect to ingredients and properties is of utmost importance in shops using synthetic sand.

Two-Sand System

Shops using a two-sand system in the foundry, i.e., backing sand and facing sand, can and do solve many of their core problems by using any one of several sands in the cores to obtain desired properties. This is permissible on the basis of the fact that the sand from the core eventually goes into backing sand and, as such, has little effect on casting finish.

Where a single, or 100 per cent, facing sand is used in the foundry, however, limitations are automatically imposed on the core sand selection due to the effects on the molding sand and ultimate effect on the castings. Therefore, large quantities of miscellaneous sands having widely different grain fineness and distribution cannot be used in the coreroom in this shop. More than 99 per cent of all the cores are made from the local bank sand.

The primary consideration in developing a core sand mixture is that of making a core which will result in the production of consistently good castings in the foundry. However, any core which fails to collapse properly and disintegrate at the mold shakeout represents a loss of good sand to the system. If there are many cores of such nature being used, the sand normally lost through adherence to the castings is not entirely replaced with core sand and the volume of molding sand in the unit is reduced.

In order to maintain the volume of sand required to operate the unit successfully, it then becomes necessary to feed new raw sand into the system, increasing labor and materials cost and upsetting control of the molding sand. Core mixtures are consequently developed not only to produce good castings, but also to produce desirable and economical conditions on the molding sand systems.

Standard Mixtures Developed

A number of standard core sand mixtures have been developed to take care of the major core production requirements. For these mixtures, standards have been set up for moisture, green compressive strength, and baked tensile strength. On each shift, samples of sand from each type of batch made are tested for these three properties.

The baked tensile tests are made on briquettes baked in the standard laboratory oven. As a check on production baking, briquettes are frequently put through the production ovens. Minor adjustments of the various ingredients to maintain the accepted standards are made by the sand control laboratory on the basis of the routine tests.

No matter how well core mixtures are made and controlled, the potential benefits are washed away if the sand handling practice, coremaking and baking equipment are improperly controlled.

Many core troubles in the foundry which are ascribed to the properties of a core mixture can often be traced to soft blowing or ramming, faulty venting, incomplete baking, overbaking, etc.

Molding Sand Control

General Control Aspects of the Molding Sand Equipment—Automatic Jolt-Squeeze Molding Machines. When automatic jolt-squeeze equipments are used, much of the "human element" can be eliminated in making a mold because the number of jolts and extent of the squeeze can be standardized to suit the job, and are thus taken out of the operator's hands. With such equipment, and very close control of molding sand properties, high mold production with a minimum of scrap can be attained.

On the other hand, unless care is exercised in making and maintaining a good "set-up" as far as machine, flasks, squeeze heads, etc., are concerned, it is possible to make a lot of scrap in a short time, even though good sand is supplied. Scrap can also be made by an operator who fails to observe the simple rules of the job, such as completely filling the flask with sand and striking it off before squeezing.

Shakeout Sand Cooling Drum. The shakeout sand cooling drum, through its functions of cooling and drying the shakeout sand, permits much better control of the molding sand. When the temperature of molding sand can be kept down, its moisture content can be more closely regulated because evaporation is minimized. Hot molding sand tends to stick to the patterns due to the formation of condensate. This tendency is eliminated with cool sand.

Sand Drying

The drying of the shakeout sand in the cooling drum has an indirect, but marked, influence on casting finish because it permits more efficient screening of this sand than would be possible with wetter sand. The drier the sand, the smaller the screen openings that can be used without fear of "blinding" them, and the greater the proportion of core butts and lumps that can be screened out.

The removal of "fines" which are picked up by the air stream in the cooler is very desirable from the standpoint of maintaining permeability and reducing seacoal ash, dead clay, etc., in the system.

By reducing the moisture of the shakeout sand, more water can be added when re-mulling the sand. This is an advantage when clay is being added in slurry form because it permits a thinner, easier flowing slurry to be used.

Separate Shakeout Sand and Spill Sand Bins and Screens. As previously mentioned, dry sand can be screened more effectively than wet

Written discussions of this paper are solicited for publication in future issues of "American Foundryman" and/or bound volume of "Transactions." Discussions should be sent to Secretary, American Foundrymen's Association, 222 West Adams St., Chicago 6.

sand. Shakeout sand is relatively dry as compared to spill sand. It also contains core butts, lumps, etc., in large quantities, whereas spill sand is relatively free of them. If these two sands were dumped in together, effective screening would be impossible. With the separate screens and bins, a fine screen can be used for shakeout sand and a coarse screen for spill sand to maintain a molding sand of facing quality.

Reconditioning Methods

For reconditioning shakeout sand, clay, seacoal, and a large quantity of water are required. For reconditioning spill sand, only a small amount of water is required. It is obvious that if these two sands were allowed to mix in varying proportions as they returned from the molding line (that is, collected in one bin) the problem of adjustment of clay, water, and seacoal to obtain uniform sand from the muller would be extremely difficult. By providing separate bins, the feeding of each type of sand to the muller may be closely controlled and additions made in accordance.

Clay Slurry Equipment. The primary purpose of mulling a sand is to coat the sand grains with a film of clay. When clay is added in slurry form the sand grains are quickly and thoroughly coated with clay since the water acts as a carrying agent. Therefore, a minimum of mulling is required to develop bond. This feature is of exceptional value where large volumes of sand are being conditioned continuously and mulling time is limited.

When using clay slurry for rebonding, less clay is used in the system because ineffective clay and clay balls are kept to a minimum. Aside from the savings in material and labor, the reduction in amount of clay used has favorable effects on the sand properties:

1. Permits use of lower moisture standard for temper at desired green bond.
2. Increases permeability.
3. Increases flowability—an important factor in jolt-squeeze molding.

The rapid response of the sand to clay additions in slurry form enables a more positive control of green and dry bond to be exercised. This feature is in sharp contrast to the slow action of clay added in the form of a dry rebonding mix (sand and clay) where mulling is the principal means of making the clay effective. "Overshooting" or "undershooting" bonding additions is much more prevalent when dry rebond is used.

Continuous Type Muller. Although it is possible to "match mull" sand for a continuous molding unit, where very large quantities are to be handled several such mullers and considerable labor are required. The continuous type muller has been found to fit into this foundry's systems much better, involving relatively little space and minimum labor. Mulling action can be roughly checked by means of the load ammeter on the drive motor. Other factors remaining constant, the extent of mulling (work) is proportional to the load ammeter reading.

Mixing Control

From a control standpoint, it is vitally important that the muller shoes be renewed and properly set at regular intervals, otherwise the system builds up ineffective clay while the green bond is actually falling. As previously mentioned, this action is particularly acute if dry rebond mixture is used to add clay to the systems.

Tempering Bins. Instead of storing large quantities of shakeout sand ahead of the muller, as is common practice, in these systems the sand is stored in two large tempering bins after mulling. By feeding alternately from the bins a degree of moisture equalization and tempering is obtained. With ample storage capacity, "turnover" of the sand is slow and molding sand temperatures can be kept down.

Revivifier. The sand discharged from a tempering bin is usually packed and chunky. The revivifier serves to aerate it thoroughly before it goes out to the molders. This treatment materially improves an important property of molding sand —flowability.

Routine Control of Molding Sand —Routine Tests. Standards for moisture, permeability, and green compressive strength to be maintained on each unit differ considerably due to the type of castings being made on the lines. Moisture standards range from 4.0 to 4.8 per cent, permeability from 40 to 60, and green compressive strength from 8 to 10 psi. Hourly tests for these three properties are made on sand samples from each of the four systems.

A dry compressive strength test and a green tensile strength test are made each shift.

System sand distribution curves are plotted and percentage of clay and seacoal are determined once a month.

Moisture Control

Water addition to the sand for desired moisture is made by means of the clay slurry. An indexed hand valve in the slurry line to the muller is used to regulate the flow of slurry.

Factors affecting moisture control are:

1. *Sand "turnover."* This term means total sand, both shakeout and spill, being mulled per hour. This is affected by the amount of shakeout sand and amount of spill sand returning. Increased tonnage requires more water.
2. *Relative amounts of shakeout and spill sand being mulled.* The relative amounts of these sands being mulled will alter water requirements as one sand is higher in moisture than the other.
3. *Temperature of sand.* The hotter the sand becomes, the more rapidly evaporation takes place and the more water is needed.

Temperature of the sand is influenced by the volume of sand carried in the system, bridging of the bins, rate of molding, and temperature inside the foundry.

4. *Types of jobs being poured on the lines.* The amount of water to be added is also influenced by the size and shape of the castings with respect to flask size, and by the relative amount of cores involved.

Bond Control

Clay addition to the sand is made in the form of slurry. To increase or decrease the clay addition, the speed of the screw feeder on the clay bin is adjusted to deliver more or less clay to the slurry preparation tank. The rate at which water is added to the tank is held constant, so the slurry consequently is increased or decreased in concentration.

Bond control of a system is affected by: (1) *Sand "turnover."* (2) *Relative amounts of shakeout and spill sand being mulled.* (3) *Types*

of jobs being poured on the lines. Large additions of new sand to the system via cores require proportionately large clay additions for bonding and vice versa. (4) *Condition of muller blades.* Ineffective mulling will cause the bond of the sand to fall even though the proper percentage of clay is maintained in the system.

Permeability Control. The permeability of the sand can best be controlled by close control of the many factors affecting it, among which are:

1. *Grain size and distribution of the sand.* As previously mentioned, this is governed primarily by choice of core sand.

2. *Amount of moisture, clay, and seacoal in the sand.* Increasing percentages of any of these in the sand cause decreased permeability.

3. *Percentage of miscellaneous fines.* Aside from the clay and seacoal, other fines such as dead clay, seacoal ash and coke, and dust from broken-down sand will lower the permeability of the molding sand.

4. *Temperature of sand.* Increasing sand temperature lowers the permeability of the sand.

Control—Seacoal

Seacoal additions are controlled by regulating the speed of the screw feeder on the seacoal bin.

Seacoal is used in the sand to reduce "burn-on" and improve casting finish. Aside from its low cost, it has few virtues and several disadvantages, among which are:

1. Reduces permeability of sand due to large amount needed (5 to 10 per cent).

2. Leaves ash and coke in the sand.

3. Difficult to control properly.

A satisfactory method of testing for effective seacoal content quickly and accurately has not been devised. For this reason, in routine control reliance is placed on a combination of experience, knowledge of jobs running in the unit, and visual inspection of castings as they come from the shakeout, as guides in regulating seacoal content.

Poor regulation of seacoal has serious effects not only upon the castings, but upon the volume of sand in the system and hence upon control of other additions. When excessive quantities of seacoal are used, misruns, blows, and cold shuts prevail in the castings. When insufficient seacoal is used, the sand burns onto the castings, resulting in increased cleaning costs and unsatisfactory finish.

Under the latter condition, the sand volume is lowered rapidly in the system due to increased amounts of sand adhering to the castings. Sand must be added to the unit at extra cost to offset this loss.

Sand Records. When large quantities of molding sand are being conditioned daily, as they are in this plant, accurate records of all materials and tests form an invaluable part of sand control. Such records, when correlated with tonnage of iron poured, percentage of scrap, etc., can give a clearer picture of sand performance and actually can be used as a guide to control.

In addition to offering a useful check on performance of raw materials, sand system records often assist in detecting unfavorable core or molding sand practices that otherwise escape the sand supervisor.

Conclusion

Much of this paper has been devoted to a description of equipment and tests designed to enable good molding sand and cores to be furnished to the foundry. Whether or not this goal is reached always depends upon the proper maintenance and operation of the equipment, and upon the close attention of foundry supervisors to the details of good practice which collectively constitute what is known as "control."

JOINT COMMITTEE

Prepares Foundry Education Plans

ON October 5 at the Hotel Cleveland, Cleveland, a joint meeting on foundry education was called through the efforts of the Malleable Founders' Society, Cleveland. Invitations had been extended to the Steel Founders' Society of America, Gray Iron Founders' Society and American Foundrymen's Association to participate in the meeting to see if a cooperative movement could not be started to secure better supervisory and executive personnel for foundries.

Anthony Haswell, Dayton Malleable Iron Co., Dayton, Ohio, representing Malleable Founders' Society, was elected chairman of the committee and presided over the meeting. In starting the discussion he quoted numerous examples of neglect on the part of foundries to take steps to supply themselves with properly trained personnel. Agreeing that something should be done the committee turned to how the problem should be attacked, what schools should be interested, what courses proposed and where will the students come from for these courses.

A good many opinions were advanced as to how the problem should be attacked and considerable discussion on scholarships and cooperative training resulted. Then when the afternoon session convened, the committee discussed its over-all aim. It was decided that the over-all aim should be to undertake activities for the purpose of developing these three phases: (1) Work with high schools on a local community basis, selling the staff and pupils on the foundry industry; (2) Contact trade schools and technical institutions for the purpose of developing curricula in foundry practice; and (3) Develop the possibility of degree courses and facilities at universities.

Inspection Procedures Report Needs Explaining

A committee report published in August, AMERICAN FOUNDRYMAN and written by Chairman Carleton C. Hitchcock, Inspection Procedures Committee, Aluminum and Magnesium Division, requires an explanation.

The article failed to note Chairman Hitchcock's committee affiliation and to which branch of the industry his article had reference. It should be stated at this time that the writer was referring to the problems of the light metals industry only.

CAST IRON FOUNDRY PRACTICE

United States Wartime Developments

By James S. Vanick, Metallurgist,

International Nickel Co.,

New York

• ***Official A.F.A. Exchange Paper presented before the French Foundry Technical Association at the first postwar French Foundry Congress in Paris, Oct. 19-20, 1945.*** ***The United States foundry industry adjusted to the almost exclusive production of war castings and developed practices to meet the greatly increased demands.***

THE author has chosen to write this review in a conversational tone as though exchanging experiences with French friends in the industry. With the advent of the war, communications stopped, and at about that time this review begins. An industry unprepared for war hastened to convert its men, materials and machines into the products for war.

Some gray iron foundries converted completely to the production of aluminum and lightweight alloy castings. The aircraft production program called for multiplying the output of lightweight alloys by approximately 10, and a corresponding increase in lightweight alloy casting production followed.

Production Shift

The foundry industry was also warned that steel would be needed in unprecedented quantities. Steel casting production trebled in quantity. Gray iron production, which had steadily increased up to the opening of the war, increased moderately but shifted in character. With these changes in the industry there was a corresponding migration of skills from one class of work to the next.

In the gray iron industry, production shifted to the manufacture of engine castings, naval and army equipment and munitions. In the course of this change, commercial castings such as automotive, stove and furnace, enamelware, pipe and water works castings became casualties almost as completely as if the country had been invaded and its production stopped.

The facilities for production were converted to the manufacture of bombs, shells, grenades, etc., while pipe shops, which were expert at centrifugal casting, applied their skill to the manufacture of guns, hollow shafts, aircraft cylinders and similar necessary equipment. Some of the most interesting accounts of technical achievements in these fields will emerge in time in the technical press.

As in any similar emergency, a shortage of men, materials and machines accompanied the conversion and production problem. The War Production Board was organized and staffed with able men taken from industry. These men were equipped from their own experience with statistics upon the capacity of industry and they set out to allocate materials and machines in amounts proportional to available manpower.

In an effort to "hold the line" on the cost of commodities, the Office of Price Administration was created, and foundrymen were faced with an acute need to place their cost accounting methods under the cold appraisal of Government officials who were not interested in profits. From this experience, much good will follow. Many foundrymen learned about the treachery of hidden costs concealed in their earlier and less exacting methods of doing business. Each producer filed a standard method for computing costs, which he was compelled to maintain.

This element of conversion brought with it considerable difficulty, particularly as shops moved from an operating schedule of 40 to 48 hours per week to 70 hours per week and operated two shifts or the necessary multiples to keep in production day and night. These changes brought with them overtime pay and wage incentives which added to the prob-

Fig. 1—Carousel system—(A) mold placed on table, (B) facing applied, (C) mold rammed, (D) sand struck off, (E) pattern drawn and mold transferred. Sand for the operation comes from overhead bin. Surplus sand falls through floor grating.

lem of cost accounting and made survival more impressive. Some foundries completely converted their practices and production in the course of this interval, while others gave up in the same time through inability to obtain men or materials or to operate at a profit.

Government authorities took charge of raw materials and, through the allocation system, controlled the production of castings.

Fig. 2—Eight copes and eight drags molded during each revolution of turntable.

Certain foundry products such as sand and fuel were in a comparatively abundant supply, while pig iron, scrap and metal supplies had to be diverted when necessary from one destination to another. This compelled foundrymen to practice substitution and conservation in such a way that operations were not always economically sound. Some of the technical features of this practice will be dealt with later.

With some Government authorities allocating materials via the War Production Board, and other Government authorities fixing prices through the Office of Price Administration, while taxes, manpower and other management problems rose, the foundrymen had to exercise much versatility to survive. The Government organizations did

Fig. 3—Typical conveyor line molding. Sand from overhead hoppers is delivered to molding machines whose tables approximate elevation of conveyor trays.

Fig. 4—Carrying its supply of molding sand, the large machine moves along center of shop ramming molds on either side.

an excellent job, the history of which may remain one of the silent but important contributions to the winning of the war.

Ably assisting foundrymen through the difficult readjustment from civilian production to military production were such organizations as the Gray Iron Founders' Society, which worked upon allocations of manpower and materials, cost systematization, safety and wartime security regulations and many other management problems. The American Society for Testing Materials worked up new specifications and necessary wartime adjustments to others. The American Foundrymen's Association acted upon technical matters, many of which are mentioned in the text of this paper and in other articles.

In cooperation with the War Metallurgy Committee of the National Academy of Sciences, an American Foundrymen's Association committee succeeded in assembling data[1] that led to an American Society for Testing Materials specification for cast iron for use at elevated temperatures. Such cooperation was not unusual.

Regional groups, combining practically all of the local units of the different engineering societies, pooled their information and made it available to manufacturers of war material. These groups assembled on short notice for emergency discussions on topics related to war production. In the region of the City of New York, this group was known as the Engineering Societies Committee on War Production.

Sand, Refractory, Mold and Core Materials. Among mold materials in the gray iron foundry, some progress seems to have occurred through the increased use of synthetic mixtures made up from a sand of predetermined grain size and shape with the bond supplied by bentonite or equivalent types of binders. Natural bonded sands continued in favor where supplies and economics and supervisory control were favorable to their use. Cement bonded molding sands continued, at least, to hold their place.

Outstanding developments followed divergent courses. Some supervisors attempted to develop specific sand mixtures to fit exacting requirements, especially where large quantities of similar castings were in production.

In the jobbing shop, where miscellaneous castings and cores had to be made, the interest was directed toward synthetic mixtures bonded with bentonite and cereal binders to make the sand suitable for all types of molding machines. Cores could be made from the same sand mixture, thus adding to the simplification. This provided the simplicity that was needed to relieve supervision without serious injury to the quality of the resulting castings.

The addition of silica flour to molding sands and cores contributed toward producing strengthened mixtures. In some cases, iron filings offered some improvement to core sands.

Molding. Some improvement in the mechanization of sand conditioning and sand conveying occurred, all designed to bring this material more rapidly to the molding machines wherever large volume production was involved. In some cases new installations were made embodying the general principle of bringing in new sand through overhead hoppers and retrieving waste or used sand through underground channels.

A favorite type of mechanized molding might be described as the small and large carousel system. In this construction the small carousel, mounting two or more molding machines, revolved with its crew and equipment and discharged its flasks to the large carousel, which conveyed them to the pouring stations and shake-out. Descriptions of this mechanization have appeared in the trade papers, and Figs. 1 and 2 illustrate some of them.

Molding machines for molds and cores contributed their specific

Fig. 5—(left) Squeezer-type machines mold large numbers of nickel-chromium-copper alloyed iron castings.

Fig. 6—(below) Type of castings made in molds shown in Fig. 5. Ball rings for ball and socket joints in aircraft exhaust manifold.

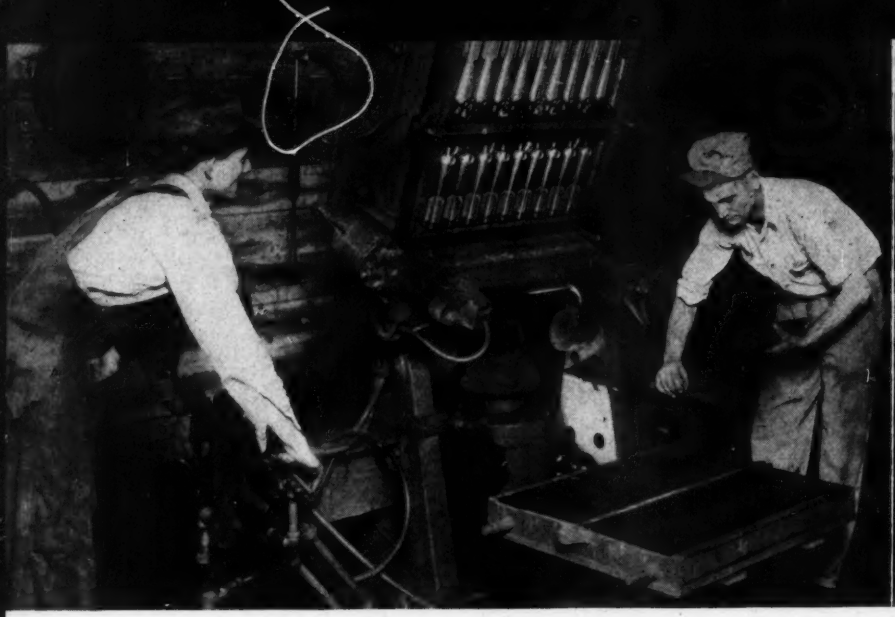


Fig. 7—(above) Machine molding of practice bombs for mass production. Fig. 8 (right) Stacked molds (also inclined).

improvements toward production. There are several varieties, each emphasizing its special merits, but the general trend was toward push-button control of the actuating mechanisms which brought sand (the raw material) to the molds, packed it in place, moved the finished mold along toward the pouring station with a minimum of lifting and handling (Fig. 3). Only one of the largest and one of the smallest types of machines are mentioned in the following text.

Molding Machine Types

Molds for large or irregular shaped castings were made up chiefly with the help of sand slingers (Fig. 4). This type of molding machine varies in detail, but its chief asset is its maneuverability, which enables it to quickly supply large volumes of sand to irregularly shaped molds.

At the other end of the scale, small molding machines of the squeezer type were worked to their accustomed capacity of 250 molds per man per 8 hours, while in exceptional cases even larger numbers were delivered. Figures 5 and 6 illustrate the production of this type in a small foundry engaged in the production of a large number of small castings.

Drying ovens with circulating heat and controlled atmospheres have become typical of everyday foundry equipment. Portable gas- or oil-fired hoods for drying large molds assisted in expediting production. Infra-red lamps have been used successfully for drying molds as they progressed along conveyors to the pouring station.

The unprecedented demand for castings upon certain industries, such as the machine tool builders, required that their foundries multiply production tenfold in some cases. For example, a shop producing 150 tons per month was required to produce 1,500 tons per month. Where men, machines and materials were available to do this task, limitations often occurred in floor space. The problem was solved by stacking the molds one on top of the other as high as it was possible to go and still provide clearance under the cranes for the pouring ladles.

In shops producing small castings such as bombs and grenades, it was common to employ this same principle, which in this case resembled methods used in casting piston rings, radiator sections, etc. Molds were stacked one upon the other with the elevation limited only by the clearance under the roof or crane in cases where large pouring ladles were used, or alternately, to the level to which men could lift the ladles where hand pouring methods were practiced. Illustrations of machine molds of this type and their assembly on the foundry floor appear in Figs. 7, 8 and 9.

Less spectacular but equally versatile methods were employed in jobbing shops where custom-made castings in small numbers were produced. Large castings would be rammed with sand slingers or massive jolt machines capable of handling large flasks. Much time was saved in floor molding by installing permanently level floors or leveling devices in the bottoms of pit or floor molds.

Centrifugal Castings. During the war, the iron foundry taught its associated metal forming industries a number of improvements and it learned a number in return. Centrifugal casting achieved new high stages of accomplishment. Shops which had been accustomed to making centrifugally cast pipe, succeeded in producing alloy steel cylinders for aircraft, hollow steel shafts for marine service, and small diameter, 75 mm. (2.9 in.), pipe, 10 mm. (0.393 in.) thick and 7.5 meters (24.6 ft.) long, made of alloy steel of the 18 per cent chromium-8 per cent nickel or 25 per cent chromium-20 per cent nickel alloy steel and with flanges welded on.

Fig. 9—Pouring nickel bronze in molds stacked two high.

Some of these activities were related to the centrifugal casting of gun tubes of steel whose production had been established long before the war. Vertical spinning machines as well as horizontal spinning machines were developed for various purposes. The nickel - chromium-molybdenum cast iron lining in a steel shell type of casting became an important component in the form of an aircraft brake drum. Figure 10 illustrates a cross-sectional view of this product.

Vertical axis machines were used for casting gear blanks and flywheels, while clusters of castings in the familiar "Christmas-tree" formation (Fig. 14) were produced by the centrifuge casting principle. The scarcity of forging hammers led to the development of centrifuge die cast parts[2] which possessed close dimensional tolerances in addition to high quality. Some of these castings are made in a carousel type of spinning machine in which molds are spaced at regular intervals around a circle, poured from and spun around a central axis rather than the usual practice of spinning castings about their own axis.

The trend toward dimensional accuracy was also accentuated by progress in the application of the "lost wax" process to the production of precision castings. The ability to produce castings which approximate finished dimensions without machining is bound to attract the manufacturer whose products may cost 50 to 100 times more to machine than they do to cast. An accuracy of about 0.001 in. per in. is promised, and a higher order of accuracy may develop with experience in computing algebraically the thermal expansion and pattern-shrinkage of pattern, wax, mold and casting.

Fig. 10—Cross section of typical centrifuse brake drum showing steel-backed high-carbon nickel-chromium-molybdenum alloy cast iron braking surface. Composition range, per cent, total carbon, 3.70-3.90, silicon, 1.45-1.65, nickel, 1.35-1.55, chromium, 0.30-0.40, molybdenum, 0.30-0.40.

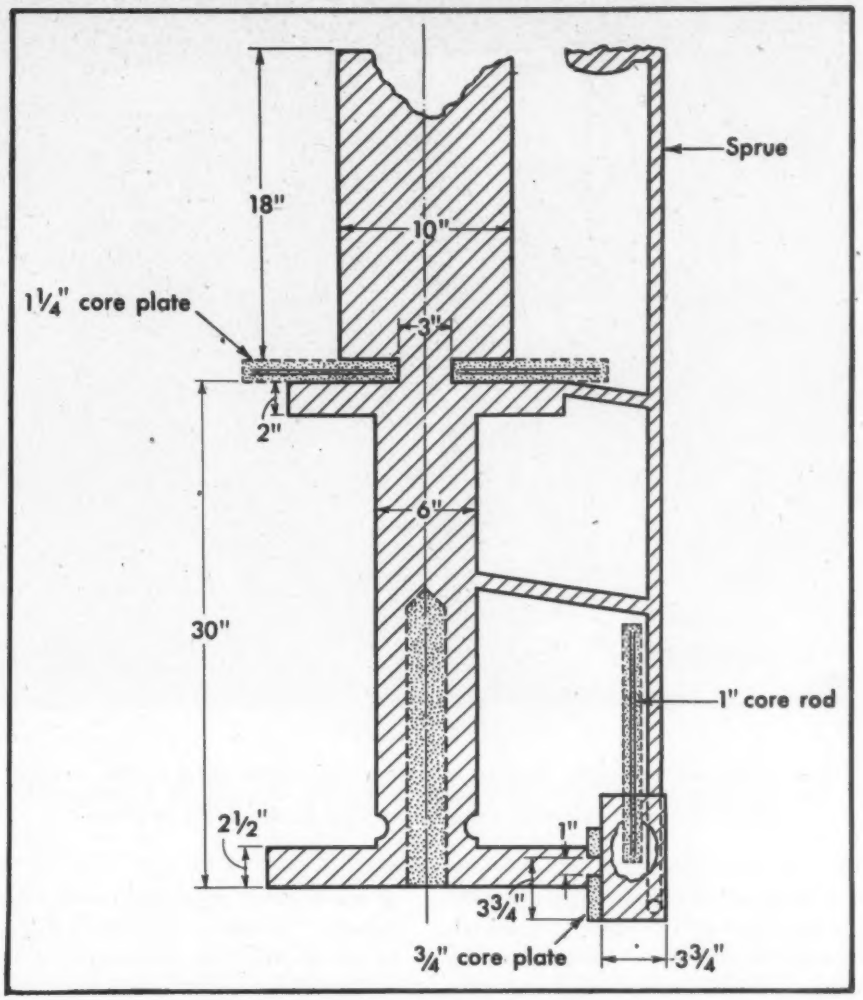


Fig. 11—Sketch showing gating practice for nickel-chromium-copper alloyed casting. Step gates, Williams riser (atmospheric pressure supplied by 1-in. core rod), gating through the riser and knock-off risers. Note relative dimensions and design of risers, riser connections and gating system. Freezing may be traced from thinnest sections and coldest metal to heaviest section and hottest metal in the risers.

Research upon refractories, facings and binders used in the precision casting process is in progress, and improvements are destined to be rapid. Gating, risering and coring such castings challenges the skill of the foundryman, and mechanical aids to the rapid flow of metal such as centrifugal, vacuum or pressure casting are being developed which will rapidly extend the application of these types of foundry products.

Directional Solidification. Directional solidification, embodying old principles but requiring periodic re-examination to stimulate the interest of foundrymen, was applied, restudied and re-emphasized. The Naval Research Laboratory illustrated and emphasized the fundamental point that castings must be proportioned and gates positioned in a manner that compelled the metal farthest from the risers to solidify first. After that, solidification must progress toward the riser where the hottest metal is located.

Gating, risering, padding, chilling, flowing off, tilting molds, pouring speeds, pouring temperatures, mold and core shrinkages, etc., represent some of the factors studied in the approach toward the objective of producing cast shapes that were as sound and solid as wrought shapes. Figure 11 illustrates the application

Fig. 12—Typical mechanical charging. Electromagnet handles metal portion of stock from bins to weighing hopper. Scale registers within sight of crane cab. Coke and limestone are added to bucket which follows track to cupola charging hoist.

of some of these principles to the production of commercial castings. Foundrymen were stimulated by these activities, which were also promoted by the Steel Founders' Society.

Dependability in castings was emphasized as worth the extra time and skill required. The soundness of castings for war purposes was not left to chance, but was certified by non-destructive testing via x-ray, gamma ray, etc. The resulting experience has developed a large and expert following.

Metal Melting and Distribution. Cupola practice responded to the demand for larger tonnage and high quality by accommodating a number of readjustments. Conservation of material and manpower produced changes, some of which will remain permanently.

The foundrymen soon learned that the extra capacity obtainable from their cupolas taxed the labor available to the point where production could not be maintained without help from mechanical devices. This led to the application of mechanical charging systems for cupolas. In most cases the charging bucket is filled in the stockyard by a travelling crane employing an electromagnet to handle the metal ingredients.

These are weighed by means of a scale located within sight of the craneman's cab. Coke and limestone are cascaded onto the charge in the bucket from hoppers containing weighing or measuring devices. This operation is usually performed as a second step after the metal charge had been prepared. A third operation employs an electric hoist which picks up the bucket and moves it into the cupola where its contents are dropped.

This procedure had reduced the charging crews in foundry yards from numbers varying from 15 to 30 men, down to 3 or 4. In the course of this change, all of the heavy work of loading, weighing and conveying stock, and the hot work of hand charging which accompanied it, had been eliminated. This innovation operates in several modifications.

Figure 12 illustrates a typical installation. It was introduced in foundries melting more than 50 tons per day, but has become sufficiently attractive for foundries melting as

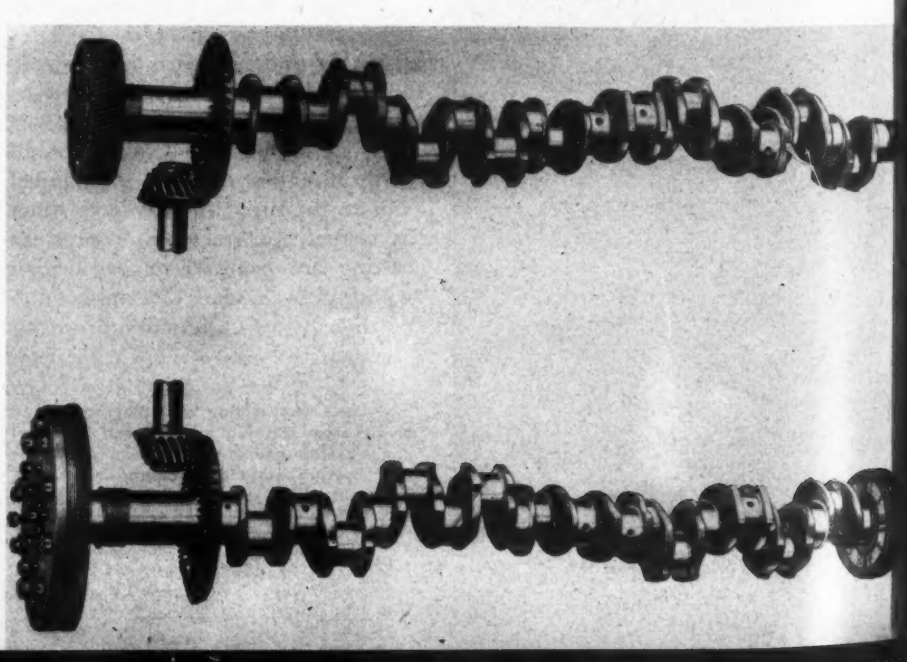


Fig. 13—High strength alloy twin crankshafts for 20-cylinder diesel engine.

little as 10 tons per day. It solved the problem of providing a sufficiently rapid charging rate to accommodate the greater melting rate accompanying the demand for increased production.

Metal removal at the spout presented a less difficult problem. Additional cranes, tramrails, motorized ladle buggies and ladles provided the handling capacity necessary to remove the additional tonnage melted. The maintenance of mixing and transfer ladles and similar equipment was facilitated by improvements in refractories, which included the application of prepared shapes such as ladle bottoms which could be laid into place in a single piece.

Similarly, slag-skimming spouts for ladles and cupola spouts were fitted in many cases with prepared refractory shapes, which saved much time in maintaining or repairing this equipment.

Emphasis on the conservation of alloys and raw materials, including machine shop turnings and sheet metal clippings, led to reclamation practices, many of which will continue in the postwar period. The reclamation of alloys by segregating and classifying machine shop turnings became an important step in alloy conservation. It was claimed that only 10 per cent of the aircraft steel originally melted found its way into the working parts of a plane.

Cupola Charging Materials

Alternating famines in pig iron or scrap or alloys developed experience with a wide range of charging materials, which demonstrated the adaptability to cupola melting of charging stock heretofore considered unsuitable. For example, the melting of briquetted cast iron borings and steel turnings from the machine shops taught the foundryman the need for compressing these materials and limiting the size of the resulting compact within ranges that would assure him of good melting and product control.

Bundles of steel clippings also had to possess a certain measure of density in order to melt well. In addition, it was found that the quantity of such scrap per charge that could be used might be limited by the pressure which the cupola blast system was able to deliver.

The briquetting procedures carried with them the need to recover oil that was introduced in the machine shops, mainly to eliminate the smoke nuisance which accompanied the use of this type of charging stock in the cupola. In some cases, the reclamation of alloys by recovery through briquetted borings caused a higher operating cost which, at the time, was justified in many cases through the need for conservation.

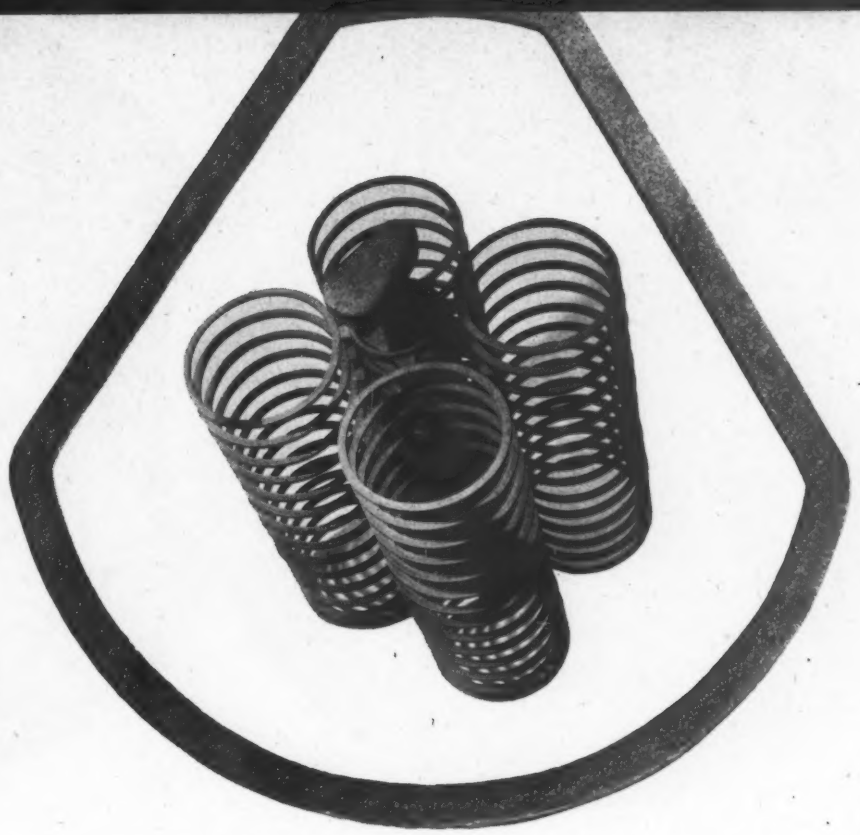


Fig. 14—(inset) Method of casting nickel-chromium-molybdenum alloyed and inoculated iron piston rings. Fig. 15—Type of specimen used to test piston ring iron.

The installation of additional hot blast systems contributed also to a substantial saving in fuel, particularly where shops were melting more than 20 tons of iron per day. In some shops the hot blast systems were used to improve melting temperatures.

While this may not have led to any economy in the use of fuel, it accomplished a more important objective in these shops through providing a hotter iron, which contributed to the production of sound castings and better physical properties. Future developments in hot blast systems may improve efficiency and reduce bulk, thus providing an additional appeal to the smaller tonnage foundries in the problem of saving fuel or improving upon control.

Additional blast humidity control systems were installed principally to improve control and thus improve quality. Foundrymen are conscious of the fact that approximately 1½ tons of air are blown into the cupola for each 2 tons of iron melted, and this volume of air may contain 15 to 30 liters of water, which takes a toll of heat units out of the fuel bed and metal charge. The increased loss in carbon, silicon and manganese attending the use of a humid blast could be eliminated by operating to a standardized humidity of the blast.

Careful research work in the laboratory upon these subjects,[3] when converted to commercial practice, offered foundrymen some measure of the influence of these factors upon the quality of the product or the economy of the process. These details of cupola operation, involving the study of the size and density of the metal and fuel charging stock, accompanied by better control over the temperature, pressure, volume and humidity of the blast, led to substantial improvements in practice which will lead the foundry industry to operate at new high standards in the future.

The restricted availability of high grade charging stock often forced foundrymen to use desulphurizing and other purifying fluxes. In the

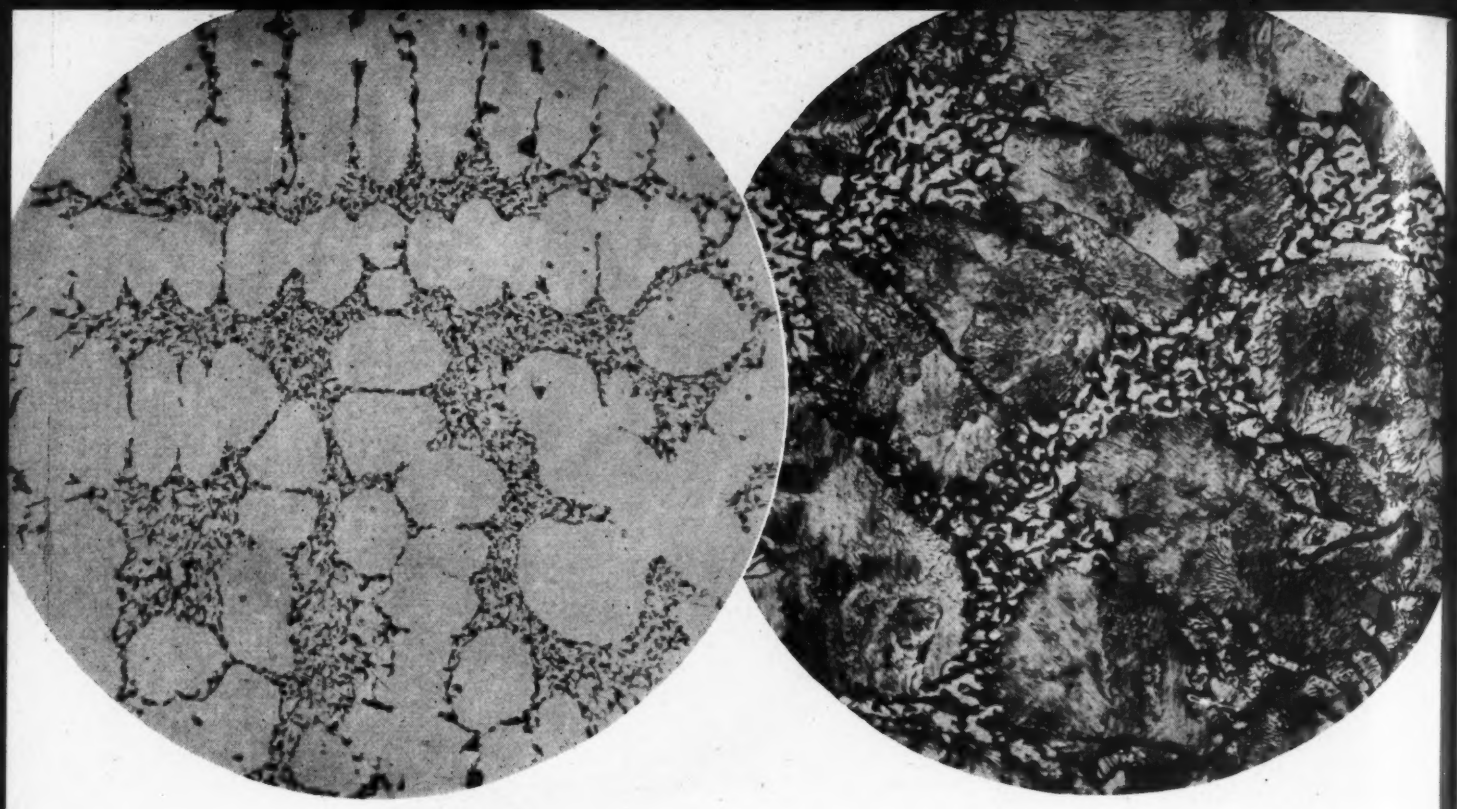


Fig. 16—(above) Photomicrograph of untreated machine tool iron near surface. Unetched, 250X. Fig. 17—(right) Same iron shown in Fig. 16. Etched, 500X.

postwar period, many of the difficulties related to this problem will be eliminated through the selection of better raw materials. The practice of duplexing by employing the electric furnace as a hot metal receiver and metal refiner gained further support. Castings requiring close control over composition or properties lent themselves much more readily to this duplex type of melting.

Weighing and measuring devices for closely controlled furnace and ladle contents were required. Common practice consisted of sampling the cupola metal by making preliminary analyses or chill tests and adjusting the metal in the electric furnace prior to pouring. With this type of control, some of the metal for high strength castings such as the crankshaft, gear, camshaft, and similar shapes could be easily prepared, alloyed up to a level necessary for the casting section and poured into molds, resulting in a product possessing strengths of from 60,000 to 100,000 psi.

Cupola melted irons of this type also were produced in large volumes. They readily exceeded the 60,000 psi. minimum tensile strength, and in special cases they travelled the entire high strength route to values exceeding 80,000 psi. Figure 13 illustrates a difficult crankshaft made from a nickel-chromium molybdenum alloyed metal.

The American Foundrymen's Association and the American Society for Testing Materials' organizations have endeavored to simplify the problem of procurement and production of specification grade material. Two additional important factors have contributed to the ease of producing cast irons of this type: (1) alloys and (2) inoculants.

With the introduction of alloys and inoculants it has become possible for small tonnage jobbing foundries to standardize upon a single semi-steel mixture, containing 40 per cent or more of steel, and from it, by means of alloys and inoculants, produce the entire specification range of No. 20 to No. 60* American Foundrymen's Association and American Society for Testing Materials cast irons.

By this device it is possible for the foundryman to treat a metal mixture of this type at the cupola spout or upon transfer from the mixing ladle by employing varying amounts of alloys and inoculants to suit the specification requirements of different castings. Since the molds for these castings may not all be ready for pouring at one time, the flexibility which the method provides enables the foundryman to treat his standardized mixture over a longer melting interval in the course of which molds are completed and prepared for pouring.

In production foundries handling large quantities of similarly shaped castings, it has been possible with the help of alloys and inoculants to produce very small castings such as individually cast piston rings, for example, to strength levels exceeding 65,000 psi. and keep them machinable as well as in good microstructural condition as regards resistance to wear, by making such castings conform to predetermined types of graphite structure (Figs. 14 and 15, and Tables 1 and 2).

In this connection, again the co-

*Numbers correspond to tensile strength in lb. per sq. in. (psi.), viz:

Iron No.	*Psi.*	*Kg/mm*
20	20,000	14
40	40,000	28
60	60,000	42

Table 1

TYPICAL COMPOSITIONS OF ALLOY IRON PISTON RINGS

	Composition, per cent
Total Carbon	3.50
Silicon	2.78
Manganese	0.61
Nickel	0.92
Molybdenum	1.09
Chromium	0.20
Phosphorus	0.22
Sulphur	0.067

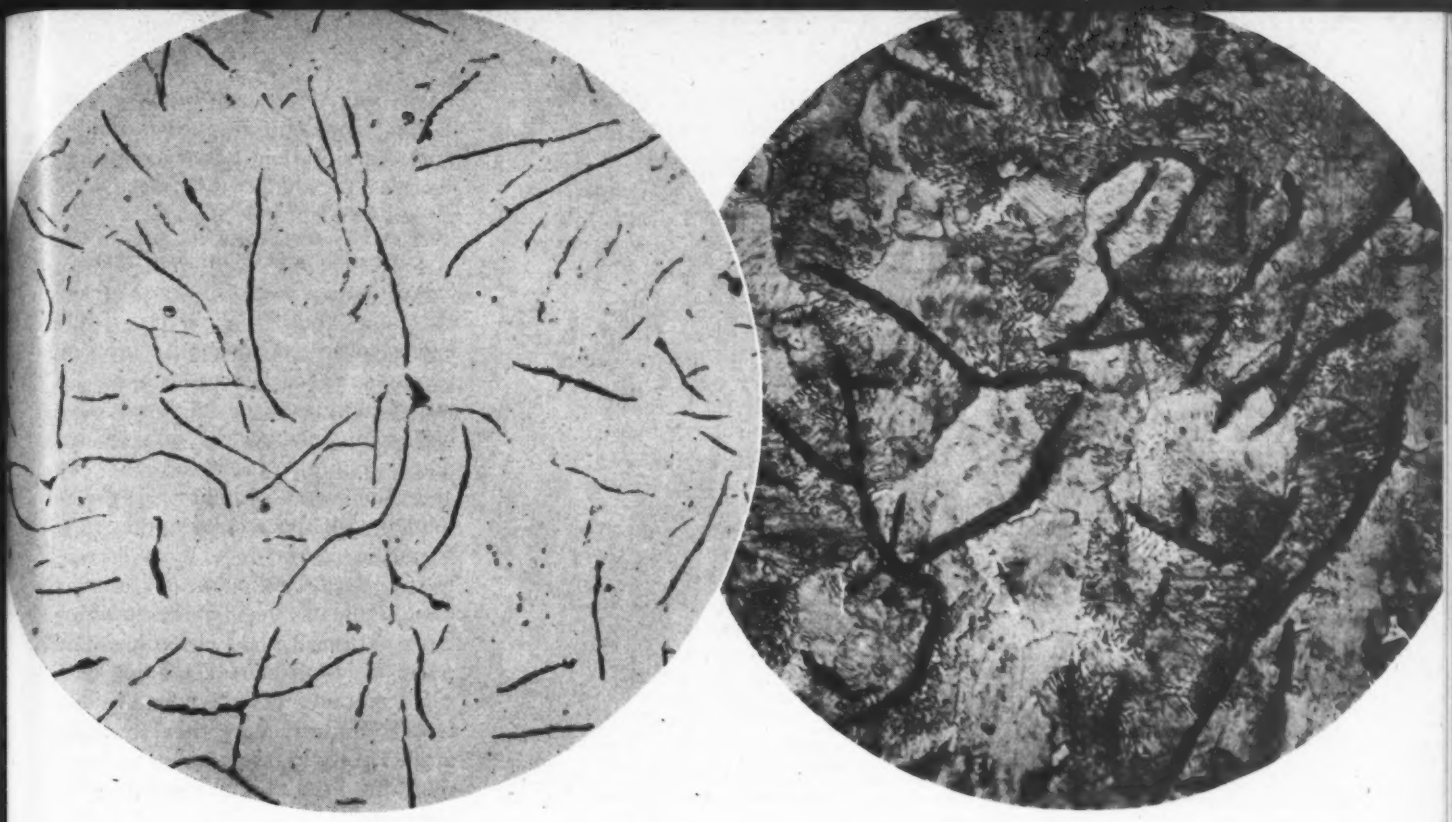


Fig. 18—(left) Photomicrograph of machine tool iron near surface, inoculated with nickel (Type B). Unetched, 250X. Fig. 19—(above) Same as Fig. 18. Etched, 500X.

ordinated activities of the American Foundrymen's Association and the American Society of Testing Materials have assisted in providing a chart classifying the type and size of graphite flakes in cast iron. This map of graphite flake structures has been extremely useful in indicating to both producer and consumer the type of graphite desired.

Mechanism of Inoculation

Inoculation, which had become common practice during the war, is certain to continue as a tool in the hands of the foundryman for eliminating heretofore unexplained variations in the quality of his product. The mechanism of inoculation has been traced to a reaction which, when executed in its proper time and place, forces the crystallization of graphite in the stable system.

Commercial inoculants usually possess a high order of graphitizing power which is supplied through the presence of graphitizing elements plus deoxidizers and degasifiers. Their important function of stabilizing the structure of the graphite leads to the production of a narrower and more dependable range of physical properties for metal of the same composition. Along with this improvement in structure comes an improvement in toughness, machinability, wear resistance and strength.

Inoculants containing alloys, such as nickel, chromium, manganese, molybdenum, titanium or zirconium in addition to silicon, calcium, aluminum and other deoxidizing or degasifying constituents are commercially available and are used for the specific improvements they confer beyond either their alloy contributing influence or their graphite structure control. Table 3, taken from the A.F.A. Alloy Cast Irons Handbook, illustrates commercial types of inoculants.[4]

As previously mentioned, the practice of inoculation has won a large following. Among the wear resisting castings a high percentage are treated with inoculants in the course of production. In a survey of heat resisting applications of cast iron, mentioned in the following, over 40 per cent of the castings for this exacting service had been inoculated.

In certain foundries the entire output is inoculated, and the practice has become important particularly in shops producing automotive, diesel, compressor, hydraulic machinery, machine tool castings and similar wear resisting products.

Figures 16 to 19 illustrate the difference in microstructure of untreated and inoculated machine tool cast irons. The powdery graphite structure may not extend entirely through the thickness of the section, but is prevalent at the working surface, often to a depth of 10 mm. (0.393 in.), which exceeds the amount of metal removed from the castings by machining. In addition to wear-resisting structure, a good inoculant will promote uniformity in structure for irregular sections, and better machinability.

The demand for steel castings exceeded the capacity of steel found-

Table 2

Typical Properties of Cast Irons

	Standard Gray Iron for Piston Rings	*Alloyed Iron*
Tensile Strength, psi	41,200	72,400
Rockwell Hardness	101 (B)	30-C
Elastic Modulus, psi	11.9×10^6	$17.0\text{-}18.0 \times 10^6$
Modulus of Rupture, psi	.....	117,000
Izod Impact* (in.-lb.)	3	5

*Comparative values obtained from breaking 0.14×0.26×3.0-in bars in an in.-lb. Izod test machine.

Table 3

SOME TYPICAL ANALYSES OF LADLE INOCULANTS

Inoculant	Composition, per cent						
	Carbon	Calcium	Chromium	Manganese	Silicon	Titanium	Zirconium
Ca-Metal	.....	100*	.....	.....	.....	.....	.....
Ca-Si	.....	30-35	.....	.....	60-65	.....	.....
Ca-Si-Ti	.....	5-8	.....	.....	45-50	9-11	.....
Cr-Si-Mn-Ti-Ca	.....	1*	38-42	8-11	14-16	1*	.....
		1*	28-32	14-16	15-21	1*	.....
Cr-Si-Mn-Zr (3 Grades)	.....	.....	30-52	5-10	14-35	.....	1-6
Fe-Si ‡							
Graphite	90-100	.....	.....	.....	.....	.....	.....
Mo-Si **	.....	.....	.....	.....	30*	.....	.....
Ni-Si †	.....	.....	.....	.....	30	.....	.....
Si-C	28-46	.....	.....	.....	45-56	.....	.....
	50	.....	.....	.....	42*	.....	.....
Si-Mn	.....	.....	.....	20-25	47-54	.....	.....
Si-Mn-Zr	.....	.....	.....	5-7	60-65	.....	5-7
Si-Ti	.....	.....	.....	.....	20-25	20-27	.....
Si-Zr	.....	.....	.....	.....	47-52	.....	35-40
	.....	.....	.....	.....	39-43	.....	12-15

*Approximate. **60 per cent molybdenum. †60 per cent nickel.
‡Several grades containing 50 to 90 per cent silicon; also silvery pig iron (6 to 20 per cent silicon) and special iron with 5 to 15 per cent silicon. Refer to ALLOY CAST IRONS HANDBOOK, Table 94, p. 231.

ries with the result that high strength cast irons were called upon to fill in where steel could not be procured. This stimulated progress in the production of high strength irons and the cupola production of those possessing tensile strengths up to 100,000 psi., as previously mentioned. Usually strengths exceeding 60,000 psi. were considered satisfactory, and nickel-molybdenum and nickel-chromium-molybdenum types fill most needs and lend themselves as easiest to produce from the control standpoint.

In this connection a demand arose for cast iron to serve at elevated temperatures. For over 30 years the limiting temperature to which cast iron was permitted to work was 450° F. This temperature had been established by authoritative committees operating in behalf of the American Society of Mechanical Engineers.

Under pressure of the war, the War Metallurgy Committee of the National Academy of Sciences conducted a survey[1] of elevated temperature applications which revealed that for cast iron possessing a carbon equivalent of less than 3.9 no failures had occurred in service above 450° F. The carbon equivalent was defined as C + 1/3 Si + 1/3 P = carbon equivalent. The work led to the preparation of a preliminary specification for cast iron of this type.

This work was executed through a joint committee of the American Foundrymen's Association and the American Society for Testing Materials. The preliminary specification provides for gray iron pressure containing castings suitable for temperatures up to 650° F. Details may be found in the American Society for Testing Materials publications. One item in the specification requires that the cast iron possess a strength exceeding 40,000 psi.

An example of the progress that has been made in this direction occurs in the production of paper mill dryer roll castings weighing many tons each. Tensile strengths exceeding 60,000 psi. in Type C (2 in. diameter) bars, and 45,000 psi. in specimens cut from the top and bottom walls of the roll, represent properties obtainable in the high-test nickel-molybdenum alloyed cast iron that is used.

Additional progress occurred with the heat resisting and austenitic types of alloys containing chromium, nickel, copper and molybdenum in substantial amounts. Among the low-alloy irons, chromium additions up to 1 or 2 per cent accompanied by nickel, copper, and molybdenum, have been developed which possess a much greater resistance to scaling and deterioration under conditions such as prevail in the furnaces of oil stills and power plants.

Corrosion and Heat Resistance

Austenitic irons of the nickel-chromium-copper alloy type were extensively used for both corrosion resistance and heat resistance. A large quantity was employed as a ball joint member in aircraft exhaust manifold assemblies (Fig. 6) and somewhat similar uses were made in less spectacular applications requiring resistance to heat or corrosion. Heat and abrasion resisting cast irons of the type containing 28 to 30 per cent of chromium and 1 to 3 per cent of nickel, along with small amounts of molybdenum, also found employment in heat resisting applications as well as in services requiring the high resistance to abrasion.

Among the abrasion resisting compositions, the low alloyed chromium and chromium-nickel types, along with the special types containing 4.5 per cent nickel and 1.5 per cent chromium, found an increasing usage as liners for grinding mills pulverizing the minerals whose end products were essential to the conduct of the war. These alloyed irons, which could deliver from two to four times the performance of unalloyed types, had to take their turn in the matter of availability, which depended upon the government's decision as to whether the alloys were sufficiently abundant to be used for the purpose intended.

Low Expansion Cast Irons

In contrast, 35 per cent nickel cast irons of low expansivity were promptly allocated the alloys they required for such essential purposes as parts for instruments, machine tools, and precision mechanisms requiring dimensional stability throughout changes in temperature.

Very little change occurred in established practices for heat treating cast irons. Since these practices usually require time and manpower in their execution, it was, in general, less difficult to produce the properties desired in the "as cast" condition. The more leisurely schedule at which peacetime operations move may lead toward a wider application of heat treating prac-

tice in developing special properties of cast iron where such a procedure produced them more economically.

Acknowledgments

It might be explained that some of the photographs shown illustrate the principle of the practice described, while actually picturing a scene in a steel or malleable or bronze foundry. For the illustrations used in the paper, the author wishes to acknowledge the courtesies extended by: Chapman Valve Mfg. Co., Indian Orchard, Mass. (Figs. 1 and 4); Belle City Malleable Iron Co., Racine, Wisc. (Figs. 2, 3 and 12); Mir-O-Coll Alloy Co., Los Angeles (Fig. 5); Ryan Aeronautical Co., San Diego, Calif. (Fig. 6); Lufkin Foundry & Machine Co., Lufkin, Tex. (Figs. 7 and 8); Long Beach Brass Foundry Co., Long Beach, Calif. (Fig. 9); Motor Wheel Corp., Lansing, Mich. (Fig. 10); Fairbanks Morse Co., Beloit, Wisc. (Fig. 13); Koppers Co., Inc., American Hammered Piston Ring Div., Baltimore, (Figs. 14 and 15).

In conclusion, the author wishes to express appreciation to his associates in the International Nickel Co. and to friends in the industry for their contributions to the substance of this paper.

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2. Peter Blackwood and John Perkins, "Centrifugal Castings," TRANSACTIONS, American Foundrymen's Association, vol. 52, pp. 273-312 (1944).

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NEW BONDING SAND

Theory and Practice Is Advanced

SINCE the evolution of the A.F.A Technical Development Program, the Director has been continually informed about the development of several new processes of interest to the foundry industry. Because these processes are confidential, he does not have an opportunity to pass on directly to the membership what is in the future. However, one inventor has permitted a statement concerning his process, one which seems to have considerable promise. It has to do with a new theory and practice on bonding of foundry sands, both of which have been evolved through a careful study of the chemical phases of pouring molten metal into sand molds.

Seeking to overcome the deficiencies of sea coal as an ingredient of molding and core sand mixtures, a Detroit chemist and engineer has proposed chemical treatment of sand to produce a uniform coating of carbon on each grain of sand. Preliminary tests have shown considerable promise for the method which is, to say the least, a radical departure in foundry practice.

The initial object of this research was the carbon coating of sand grains to the end that they would be non-oxidizing without the addition of any extraneous material. Although extensive tests showed this method to be highly effective, it also revealed the fact that the effectiveness of any method to offset the action of oxygen was directly proportionate to the amount of oxygen present. In that water in the mold was found to be the most prolific source of such oxygen, further work was undertaken to eliminate if possible the use of water in molding. To this end the method devised for coating the sand grain with carbon and the coating so produced was amplified to make it possible to bond the sand by the surface adhesion of the coated grains. Thus although this chemically treated sand uses no water and so has the properties of dry sand, it produces under pressure a good "green" bond.

As the molten metal transfers its heat to the mold, a physical change in the coating and its adhesion produces the necessary hot strength, while the further rise in temperature, particularly at and near the surface of the mold and in the presence of oxygen, converts it to an inert gas. Two contradictory problems had to be met in the development of the process. First, the production of a compound which would produce adhesion without at any time becoming sticky, in order to provide a continuous free-flowing system. Second, in the interests of economy, the compound had to change physically to meet various progressive requirements while at the same time retaining its original chemical composition so that it could be reused repeatedly until it was finally lost as a gas in combination with oxygen. Attention was even given to minimizing the contamination of the system and thus the purity of the compound has been held to less than one-half of one per cent ash when volatilized.

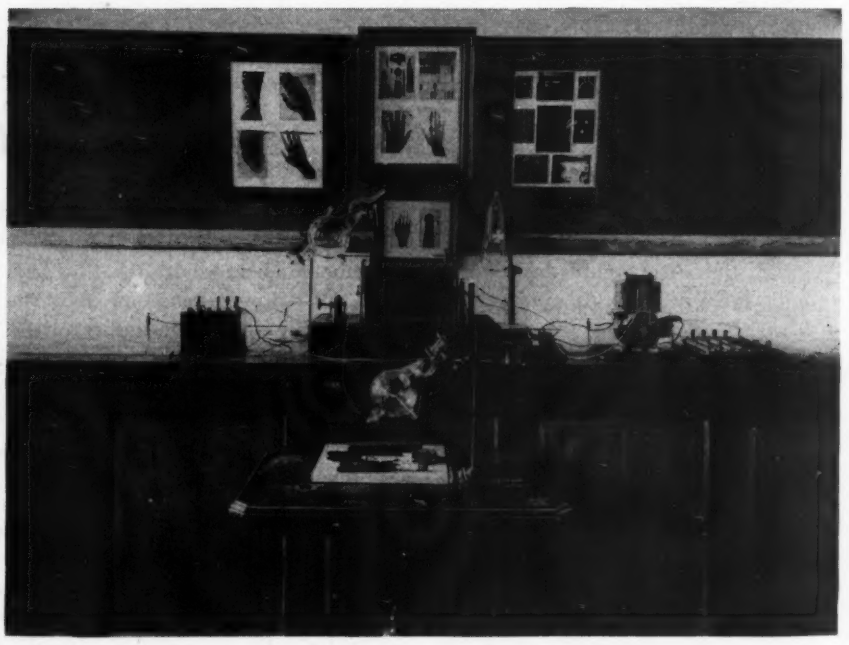
Further experimental work has been completed on converting the initial physical bond, utilized in making a mold, into a plasticized fusion, so that the sand can be used for the production of cores which will have the same inert properties as the mold. When production tests are completed on this phase, it is anticipated that both sand systems can be combined and that it will thus be possible to use this chemically treated sand continuously and interchangeably for the production of either cores or molds.

Cost Committee Stresses System for Small Foundry

THE Association's Foundry Cost Committee, at its meeting in Chicago on November 7, outlined as its major activity the stressing of foundry cost systems for the smaller foundries. The committee feels there is great need in the foundry to place all foundries on a basis where they know their cost of producing castings. The A.F.A. Foundry Cost Committee, the second oldest standing Association committee, was first formed in 1897. Its earlier work was the developing and publishing of recommended cost systems for foundries. In 1919 the committee published a very comprehensive cost accounting system. This system was issued as a special publication and also appears in the A.F.A. TRANSACTIONS, Volume 28 (1919) pages 65 to 144.

(Left)—Objects radiographed by means of early x-ray equipment shown in photograph below. Experiments were conducted at St. Ignatius College, Chicago, in 1896, one of the first institutions to pursue studies in the new radiation. (Below)—The laboratory at St. Ignatius College, Chicago, in which x-ray was demonstrated as early as February, 1896, little more than a month after Roentgen's discovery was announced. Shown are various cathode-ray tubes and the generating apparatus, with radiographic samples on the wall in the background. Note articles on the table ready for x-raying are shown in photograph above after being radiographed.

X-Ray's 50th Year



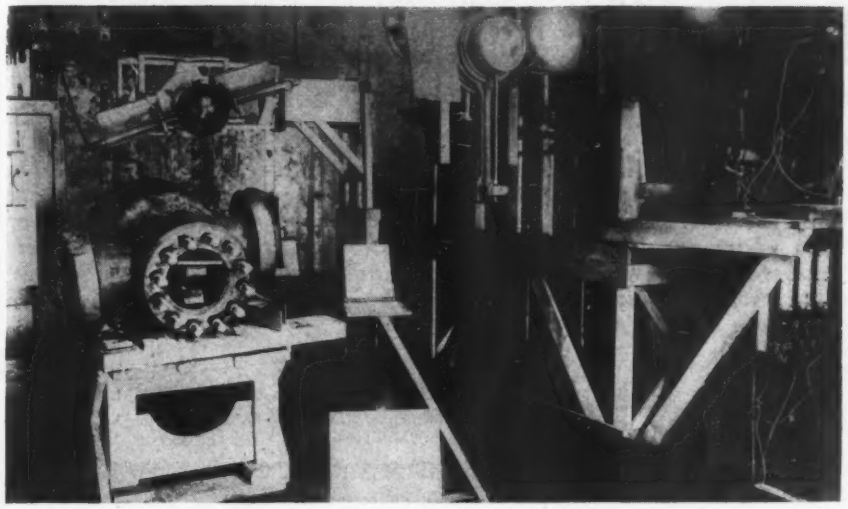
I HAVE observed something but I don't know whether my observations are correct."

Such is the modest and matter-of-fact way in which Wilhelm Konrad Roentgen wrote to a friend regarding his discovery of x-ray, which he had not yet announced to the world. This month, 50 years later, we look back on that discovery as one of the dramatic moments of history. It involved a ray that is both silent and invisible, whose existence can only be told by the effects it produces, yet which brought untold benefit to the world, through increased safety of materials used in everyday life and in increased health by diagnosis and therapy. Foundry practice today is much different from what it was only a short while ago, chiefly because of the gains in the control of production processes and quality made possible by this non-destructive method of inspection and testing.

It is significant that this year also marks the announcement, for the first time, of actual plans for the production of induction electron accelerators super-power x-ray machines which operate at voltages up to 100,000,000. These units, whose construction had just been announced when war secrecy clamped down, are being revealed in detail now. They represent the peak reached thus far in high-intensity, short wavelength x-radiation, and portend many future developments in radiography and radiotherapy. Input voltage is extremely low, being from 30,000 to 70,000 volts, as against a full 2,000,000 which must be applied by the generator to the tube of the 2,000,000-volt x-ray apparatus now in use.

How Discovered

At the 50-year mark, it is interesting to recall just how x-rays were discovered. Many other men besides Roentgen had been working with x-ray-producing tubes without knowing it, but it remained for this methodical man to track down, isolate and identify this elusive type of radiation. Roentgen alone demonstrated that a mysterious form of radiation was penetrating the black paper with which his contemporary Lenard had covered a cathode tube and that these rays would also penetrate most other materials. He was the first to realize the significance of x-radiation and to distinguish it from other forms of energy given off by cathode tubes, which caused fluoroescent screens to glow. Lenard could not



First industrial x-ray machine—a mechanically rectified 200,000-volt unit purchased by the War Department in 1922 for Watertown Arsenal. It was used to examine heavy-walled steel castings.

have discovered x-rays if he had continued with the materials he was then using, for it is not known that the screen he employed was sensitive only to cathode rays other than x-rays. Roentgen, however, used platinocyanide, which is affected by x-radiation.

While the credit for the discovery of x-rays clearly belongs to Roentgen, it is apparent that his efforts represented the logical culmination of the efforts of several contemporaries and forbears. For example, there was the high-voltage induction coil developed by Ruhmkorff; the observation by Hittrof of rays emanating from cathode tubes; the work of Sir William Crookes in developing highly-discharged tubes; and the experiments of Lenard. Jackson and Goldstein had also observed the fluorescence of certain materials when placed near Hittorf-Crookes tubes.

Famous Remark

Sound and scientific approach is illustrated by Roentgen's classic response to an American reporter's question, "And what did you think when you observed this fluorescent effect?"

"I did not think," came the rejoinder. "I investigated!"

One of the first radiographs made by Roentgen, as reported by his biographer, Glasser, was that of welded zinc. This showed a considerable lack of homogeneity in the specimen. He also radiographed a shotgun, which caused considerable interest in the German and Austrian ministries of war. Early in 1896, the Carnegie Steel Works in Pittsburgh studied x-ray as a method of detecting flaws in steel.

The first commercial application of x-ray as an industrial tool began in the United States in 1922, when the War Department installed a 200,000 volt mechanically-rectified x-ray generator in the Watertown Arsenal. This "weapon" was used as a research tool and guided the development of better foundry techniques to meet the exacting requirements of the arsenal's standards. Even at that time, directors of the arsenal predicted that x-ray's chief roll would be that of a non-destructive testing method to provide an accurate means of establishing correct foundry technique, rather than as a production inspection tool.

GE a Pioneer

Also a pioneer in the use of x-ray was the General Electric Co., particularly in the study of methods for improving copper used in electrical apparatus.

Industrial applications for x-ray developed slowly, but they gradually assumed a major role in quality control and inspection procedure. Intensified competition and consumer demand for increasingly higher standards have changed x-ray from a strange, new tool to a *sine qua non*. The waste and inadequacy of destructive testing have become increasingly apparent as the power and latitude of x-ray go up and exposure time and consequently labor cost go down.

Diffraction — which may yet prove to be one of the broadest applications of x-ray to industry—came into its own at the same time, serving as a guide to improved materials and production processes through the examination of the internal patterns created in crystalline molecular structure.

Looking back, it can be truly said that this 50 year period closes a definite era in x-ray history, and that the next era will start off with supervoltages for increased penetration, coupled with much lower voltages which may permit the study of the inner structure of matter in units which are smaller than the wave length of light. Both are certain to have a profound effect on foundry operation.

Foundry Equipment Men Hold Annual Meeting

AT THE twenty-seventh Annual Meeting of the Foundry Equipment Manufacturers Association held at The Homestead, Hot Springs, Va., October 19-20, President Thos. Kaveny, Jr., Herman Pneumatic Machine Co., Pittsburgh, Pa., was re-elected for another year. Vice-President O. A. Pfaff, American Foundry Equipment Co., Mishawaka, Indiana, and Secretary-Treasurer A. J. Tuscany, Cleveland, were also re-elected.

New Directors of the organization were elected as follows: E. J. Burnell, Link-Belt Co., Chicago; H. T. Worthington, The Beardsley & Piper Co., Chicago; and Thomas Kaveny, Jr., were re-elected.

During the course of the meeting, several product groups were set up so as to facilitate discussion of mutual and specialized equipment problems. The following groups and their Chairmen were appointed:

Dust Control—John Hellstrom, American Air Filter Co., Louisville, Ky.

Molding Machines—H. E. Fellows, Milwaukee Foundry Equipment Co., Milwaukee.

Sand Treating and Handling — W. L. Hartley, Link-Belt Co., Philadelphia.

Blast Cleaning and Tumbling—F. W. Klatt, W. W. Sly Mfg. Co., Cleveland.

Metal Abrasives—J. F. Ervin, Alloy Metal Abrasive Co., Ann Arbor, Mich.

NEW ASSOCIATION MEMBERS

(September 15 to October 15, 1945)

• Twenty-three A.F.A. chapters reported an increase in membership for this past month—a total of 102 new members being brought into the Association. Looking back over the records we find that last year, during the same period of time, twenty-four chapters reported 239 new members with Saginaw Valley enrolling 53 names. This month Saginaw still heads the list with 13 names, while Southern California tallies 10.

Conversion—Affiliate to Company
Eaton Mfg. Co., Fdry. Div., E. L. Waterhouse, Plant Mgr., Vassar, Mich.
Conversion—Company to Sustaining
Commerce Pattern Foundry & Machine Co., Detroit. (E. J. Rousseau, Pres.).
Milwaukee Chaplet & Mfg. Co., Milwaukee. (Paul F. Rice, Pres.).

CENTRAL INDIANA CHAPTER

Ray C. Bopes, Cupola Foreman, International Harvester Co., Indianapolis.
R. E. Eastham, Fdry. Supt., Farm Tools Inc., Vulcan Plow Div., Evansville, Ind.
William Fitzsimmons, Gen. Fore., International Harvester Co., Indianapolis.
Jack W. Giddins, Asst. Fdry. Met., International Harvester Co., Indianapolis.
Thomas T. Haver, Met., Ertel Machine Co., Indianapolis.
Clifford W. Johnson, Fdry. Supt., Ertel Machine Co., Indianapolis.
Lee McLeery, Asst. Fore., International Harvester Co., Indianapolis.

CENTRAL OHIO CHAPTER

B. L. Hanna, Dist. Repr., Corn Products Sales Co., Cleveland.

CHESAPEAKE CHAPTER

Charles W. Cooper, Snapper Molder, Naval Research Laboratory, Washington, D. C.
H. S. Kepner, Fdry. Foreman, Frick Co., Inc., Washington, D. C.

CHICAGO CHAPTER

Clure H. Burge, Prod. Supt., Hammond Brass Works, Hammond, Ind.
Alan Goldblatt, Chicago Repr., Harry W. Dietert Co., Detroit.
Robert A. Heindel, U. S. Graphite Co., Chicago.
John Janiga, Coreroom Fore., Hammond Brass Works, Hammond, Ind.
Joseph F. Lange, Asst. to Supt. Fdries., Carnegie-Illinois Steel Corp., Chicago.
John Martin, Foreman, American Steel Foundries, E. Chicago, Ind.
Richard B. Paquette, Chicago.

CINCINNATI DISTRICT CHAPTER

W. L. Heppner, Fdry. Supt., Harris Seybold Potter Co., Dayton Ohio.
A. F. Tenney, Pres., Tenney Combustion Engineering, Dayton, Ohio.

DETROIT CHAPTER

Armand DiGiulio, Consulting Engr., Commerce Pattern Fdry. & Machine Co., Detroit.
John W. Heaver, Met., Mueller Brass Co., Port Huron, Mich.

EASTERN CANADA & NEWFOUNDLAND CHAPTER

Arthur Hamer, Charge Hand, Western Pattern Works Inc., Montreal, Quebec.
W. C. Rowe, Chemist, Crane Ltd., Montreal, Quebec.
***Sorel Industries Ltd., Sorel, Quebec, (J. R. Wilhelmy, Treas.).**
***Steel Co. of Canada, Montreal, Que. (C. H. Withers, Supervisor).**
Marcel Trottier, Technician, Warden King Ltd., Montreal, Que.

METROPOLITAN CHAPTER

Julius Bland, Met., Navy Department, Long Island City, N. Y.
S. C. Chi, East Orange, N. J.
Arnold E. Czechowicz, Foundryman, Hartford Elec. Steel Corp., Hartford, Conn.

MICHIANA CHAPTER

Ellis Brown, Vice Pres., Bremen Gray Iron Fdry. Inc., Bremen, Ind.
Kenneth Clark, Partner, Superior Brass & Mfg. Co., Elkhart, Ind.
Chas. Delp, Core Room Supt., Superior Brass & Mfg. Co., Elkhart, Ind.
Russell Hand, Fdry. Foreman, Bremen Gray Iron Fdry. Inc., Bremen, Ind.
Carl Windbigler, Foreman, Superior Brass & Mfg. Co., Elkhart, Ind.

NORTHEASTERN OHIO CHAPTER

J. E. L. MacAdams, Engr., Cleveland Quaries Co., Tiffin, Ohio.
Philip Ramer, Sales Engr., Atlantic Abrasive Corp., S. Braintree, Mass.
William M. Roonery, News Editor, *Steel* Magazine, Cleveland.
Malcolm D. Salinger, Supt. Patt. Dept., Cleveland Frog & Crossing Co., Cleveland.
Ye-Chun Sun, Engr., Chinese Air Force, Cleveland.
Say Co Tong, International Training Administration Inc., Washington, D. C.
Ching-Chang Yang, International Training Administration Inc., Washington, D. C.
Karl Zellner, Mgr., The Zellner Foundry Co., Cleveland.

*Company Members.

NORTHERN CALIFORNIA CHAPTER

George Carlson, Patternmaker, Enterprise Engine & Fdry. Co., So. San Francisco.

N. ILLINOIS & S. WISCONSIN CHAPTER

Harold R. Boutell, Gunite Fdries. Corp., Rockford, Ill.
Robert W. Jacobson, Gunite Fdries. Corp., Rockford, Ill.
Vito Lassandro, Prod. Mgr., Gunite Fdries. Corp., Rockford, Ill.
Ray D. Schwenkner, Asst. Prod. Mgr., Gunite Fdries. Corp., Rockford, Ill.

NORTHWESTERN PENNSYLVANIA CHAPTER

J. G. Bigler, Fdry. Foreman, Chicago Pneumatic Tool Co., Franklin, Pa.
Chas. E. Forney, Serv. Engr., Manufacturers Supply Co., Cleveland.
Andrew Lucas, Anneal Dept. Fore., Erie Malleable Iron Co., Erie, Pa.
Henry Maciulewicz, Fore., Grinding Dept., Erie Malleable Iron Co., Erie, Pa.
Frank P. Volgstadt, Fore., Griswold Mfg. Co., Erie, Pa.
Clyde William Backus, Time Study, Erie Malleable Iron Co., Erie, Pa.

ONTARIO CHAPTER

W. Chimka, Vulcan Iron Works, Winnipeg, Manitoba.
Frederick Filjeski, Inst., International Harvester Co., Hamilton, Ont.
Oswood Guy MacDonald, Manager, Diversified Alloys, Vancouver, B. C.
***Standard Fuels Ltd., Toronto, Ont., Canada. (Gerald Nash, President).**
Gordon B. Thomson, Chromium Mining & Smelting Corp., Sault Ste. Marie, Mich.
B. Douglas Weaver, Asst. Mgr., Nepheline Products Ltd., Lakefield, Ont.
T. J. Wells, Supt. of Blast Furnace, Steel Co. of Canada Ltd., Hamilton, Ont.

OREGON CHAPTER

L. E. Bufton, Partner, Silica Products Oregon Ltd., Portland, Ore.
K. E. Hamblin, Partner, Silica Products Oregon Ltd., Portland, Ore.

PHILADELPHIA CHAPTER

H. Earl Blanton, Mgr., Chester Fabricators, Inc., Chester, Pa.

ROCHESTER CHAPTER

J. Robin Davis, Ingersoll-Rand Company, Painted Post, N. Y.
Murray C. Goddard, Engr., The Symington-Gould Corp., Rochester, N. Y.

SAGINAW VALLEY CHAPTER

Robert S. Busk, Supv., Dow Chemical Co., Midland, Mich.
Harold A. Diehl, Met., Dow Chemical Co., Midland, Mich.
Stanley Glysz, Group Leader, Baker Perkins, Inc., Saginaw, Mich.
Raymond H. Klawuhn, Accountant, General Fdry. & Mfg. Co., Flint, Mich.
Robert G. Leckie, Resident Comptroller, Chevrolet Grey Iron Fdry. Div., Saginaw, Mich.
James O. Menter, Safety Director, Chevrolet Grey Iron Fdry. Div., Saginaw, Mich.
Michael P. Murphy, Prod. Dept., Chevrolet Grey Iron Fdry. Div., Saginaw, Mich.
J. Nelson Neal, Contact Insp., Chevrolet Grey Iron Fdry. Div., Saginaw, Mich.
Gordon B. Robb, Vice Pres., The Pyro Clay Products Co., Oak Hill, Ohio.
***Saginaw Pattern & Mfg. Co., Saginaw, Mich. (E. F. Booth, Mgr.).**
John Stock, Core Foreman, Dow Chemical Co., Bay City, Mich.
Harold E. Ward, V.P.-Gen. Mgr., The United States Graphite Co., Saginaw, Mich.
G. L. Wright, Personnel Dir., Chevrolet Grey Iron Fdry. Div., Saginaw, Mich.

ST. LOUIS DISTRICT CHAPTER

W. Ray Karnes, Salesman, Pickands Mather & Co., St. Louis.
Jack Sonnenfeld, Jr., Serv. Engr., Master Tool Co. Inc., Cleveland.

SOUTHERN CALIFORNIA CHAPTER

Julio E. Azpeitia, M1 1/c, U.S.S. Otus (ARG-20) San Francisco.
Richard J. Berry, Supt., Weiser Co., South Gate, Calif.
E. Ray Boylan, Melting Fore., Eld Metal Co. Ltd., Los Angeles.
Harry B. Cordes, Moulder, Price Pfister Mfg. Co., Los Angeles.
Wilbur G. Davenport, Lee Ray Co., Los Angeles.
Hudson G. Gray, Repr., Aircraft X-ray Laboratory, Altadena, Calif.
J. W. D. Griffith, Independent Fdry. Supply Co., Los Angeles.
Jack E. Patterson, Salesman, Brumley-Donaldson Co., Huntington Park, Calif.
George V. Peake, Partner, Pattern Service Co., Los Angeles.
R. J. Wallace, Westlectric Castings, Inc., Los Angeles.

TEXAS CHAPTER

Joe R. Skyvara, Owner, Skyvara Foundry, Houston, Texas.
***Henry J. LeBlanc, Standard Brass & Mfg. Co., Port Arthur, Texas.**

TWIN CITY CHAPTER

Albert W. Becklund, Fore., Northern Malleable Iron Co., St. Paul, Minn.
Arthur O. Olson, Foreman, Mpls. Electric Steel Cstgs. Co., Minneapolis, Minn.
T. H. Palmer, Mgr., Fire Brick Supply Co., Minneapolis, Minn.
Lloyd Stinebaugh, Fore., Northern Malleable Iron Co., St. Paul, Minn.
Carl W. Sundberg, Physical Lab. Asst., Mpls. Elec. Steel Cstgs. Co., Minneapolis, Minn.

WISCONSIN CHAPTER

Thomas Gross, Fdry. Supt., Harnischfeger Corp., Milwaukee.
Clifford A. Kalupa, Pres., C. A. Kalupa Sand Co., Berlin, Wis.
Robert Kauffman, Serv. Engr., Thiem Products Co., Milwaukee.
E. H. Roeming, Office Mgr., Liberty Div., Grede Fdries. Inc., Milwaukee.
Henry Seeboth, Secy., Milwaukee Bronze Casting Co., Milwaukee.

*Company Members.

OUTSIDE OF CHAPTER

Delmon F. Weaver, Pontiac Foundry Co., Ft. Wayne, Ind.
Altilio Cucchi, Engr., S.A. Talleres Metalurgicos San Martin "TAMET", Buenos Aires.
John W. R. Graham, R. A. Lister & Co., Ltd., Gloucestershire, England.
M. N. Heller, Met. Chemist, Barratt & Pillans Ltd., Transval, South Africa.
Jean Maurice Laine, Gen. Secy., Centre Technique des Industries de la Fonderie, Paris, France.
Theodoro Niemeyer, Engr., Elevadores Atlas S/A., Sao Paulo, Brazil.
Fernand Eugene Nifenecker, Engr., French Republic Government, Washington, D. C.
Joel Ramalho, Engr., Elevadores Atlas S/A., Sao Paulo, Brazil.
Royal Technical University, Stockholm, Sweden.
Carlos Teixeira, Engr., Elevadores Atlas S/A., Sao Paulo, Brazil.
H. P. R. Scott, British Iron & Steel Corp. Ltd., Warwick, England.
B. Slavin, Asst. Engr., State Rivers & Water Commission, Melbourne, Victoria.
Dr. Martinho Prado Uchoa, Engr., Elevadores Atlas S/A., Sao Paulo, Brazil.

Foundry Personalities

Thomas J. Hilliard, Carnegie-Illinois Steel Corp., Pittsburgh, has been made vice-president in charge of sales.

Mauro Garza Villareal, general superintendent, Fabricas Orion, Mexico City, Mexico, was a visitor of the National Office recently. From France came another visitor **Jean Maurice Laine',** general secretary, Association Technique de Fonderie, Paris, France. This Association corresponds to A.F.A. in France. With Mr. Laine' were **Fernand Eugene Nifenecker,** engineer, French Republic Government, Washington, D. C., and **J. N. Boucher,** engineer, Societe des Hauts Tourneaux et Fonderies de Pont-A-Mousson, Paris, France.

August Van Lantschoot after thirty-nine years with the Iowa Malleable Iron Co., Fairfield, Iowa, has resigned from his position as superintendent of that concern.

L. E. Everett

A. Van Lantschoot

Lt. Col. Leroy E. Everett has been released from active duty with the Army Air Force after serving overseas for 30 months. He has joined Lester B. Knight & Associates, Chicago. Mr. Everett was active in forming the A.F.A. Birmingham chapter, is past chairman of the A.F.A. St. Louis District chapter, and has been a staunch supporter in Association work for many years.

M. S. Burg

John Howe Hall

John Howe Hall has joined the staff of General Steel Castings Corp., Eddystone, Pa., in a consulting capacity.

Martin S. Burg, for the past three years chief chemist, Dodge Chicago plant, has joined the Certified Core Oil & Mfg. Co., Chicago, as chief chemist and technical foundry adviser.

F. L. Bender, Chicago Hardware Foundry Co., North Chicago, Ill., has been appointed supervisor of automotive equipment in addition to his present position as chief inspector.

J. H. R. Graham, R. A. Lister Co. Ltd., Dunley, Gloucestershire, England, was a recent Association visitor. He is an engineer for the foundries of the above company and is studying modern mechanized foundry practice in Chicago, Milwaukee, Detroit and other foundry centers.

Lt. William A. Meissner, Jr., U.S.N.R., recently was released from active duty with the Navy, and has been appointed director of sales, Silverstein & Pinsof Inc., Chicago.

John D. Wise, for the past few years director of purchases, Pangborn Corp., Hagerstown, Md., has been transferred to the corporation's Chicago sales office, where he will make his headquarters.

Harry L. Campbell, formerly with McInerney Spring & Wire Co., Grand Rapids, Mich., is now chief metallurgist, The Western Foundry Co., Chicago.

Paul Eisenhuth, formerly of the Chemicals Div., WPB, has been named charge of sales, Aromatic Solvents, Velsicol Corp., Chicago. **Arthur H. Carnes,** previously division sales manager, Stanco Distributing Co., has become mid-western district manager of all Velsicol products. **J. Newton Hall,** formerly of WPB, Chemical Div., has been made eastern sales manager of all Velsicol products.

Joe Sheeketski, former University of Notre Dame right halfback, has been granted a leave of absence from the Peninsular Grinding Wheel Co., Detroit, to become backfield coach on the 1945 Notre Dame coaching staff.

Herbert R. Isenburger has been added to the Editorial Advisory Board of *The Engineers' Digest.*

CHAPTER ACTIVITIES News

MEXICO CITY
Sends Petition to A.F.A. for Chapter

ON October 6 at Chapultepec Restaurant, Mexico City, Mexico, a group of 56 foundrymen from Mexico City and surrounding territory met to discuss the formation of a chapter of the American Foundrymen's Association. R. L. McIlvaine, vice-president and sales manager, National Engineering Co., Chicago, acted as "minister extraordinary" for A.F.A. at the meeting. The Mexican foundrymen were enthusiastic and are welcoming the suggestion to organize a chapter.

The group that organized the meeting consisted of the following A.F.A. members: Ernesto Villalobos, general manager, Cia. Constructora de Marquinaria S.A.; Manuel Goicoechea, general manager, Herio Malleable de Mexico, Fundiciones de Hierro Y Acero S.A.; A. Zapata, manager, Fierrio Esmaltado; Enrique Molina, production manager, La Fundicion La Mexicana; and Nicholas Covacevich, foundry supplies and equipment. R. L. McIlvaine also aided in laying the groundwork that helped bring these foundrymen together to sign the petition seeking a chapter.

Mr. Villalobos acted as temporary chairman. The men present heard Mr. Covacevich explain the many advantages offered by membership in the Association, and answered questions that were put to him concerning the Association's activities in the United States.

Following the chapter formation discussion and the signing of the chapter petition, the meeting was turned over to Mr. McIlvaine who discussed foundry practice in the United States and answered many questions following his presentation.

CENTRAL ILLINOIS
Group Proposes Association Chapter

ON Thursday, October 18, fourteen foundry executives of the Central Illinois district met at a dinner in the Pere Marquette Hotel, Peoria, Ill. At this dinner meeting a local committee was organized and started the work towards developing a petition to be forwarded to the National Board of Directors for the approval of a chapter in that district. The organization committee is as follows: *Chairman,* Ed Roby, superintendent, Peoria Malleable Castings Co., Peoria, Ill.; *Vice-*

October meeting of the Michiana chapter held at the Hotel Whitcomb, St. Joseph, Mich.

Chairman, Z. Madacey, foundry superintendent, Caterpillar Tractor Co., Peoria, Ill.; *Secretary,* C. W. Wade, foundry training supervisor, Caterpillar Tractor Co., Peoria, Ill.; and *Treasurer,* Al Martens, president, Pekin Foundry & Mfg. Co., Pekin, Ill. In addition to the officers named above, the organization committee is composed of the following: C. N. Bucklar, secretary, Superior Foundry Co., East Peoria, Ill.; Haydn Laycock, Frederic B. Stevens, Inc., Peoria, Ill.; H. J. Scheffler, vice-president, Keckley Mfg. Co., Springfield, Ill.; Frank Hayes, Capitol City Pattern Works, Springfield, Ill.; Professor Carl E. Schubert, University of Illinois, Department of Mechanical Engineering, Urbana, Ill.; Ed Burns, Illini Foundry, Bartonville, Ill.; Frank Willis, Brass Foundry Co., Peoria, Ill.; V. W. A'Hearn, Midwest Pattern Works, Peoria, Ill.; J. Kolb, pattern shop superintendent, Caterpillar Tractor Co., Peoria, Ill.; and F. W. Shipley, foundry manager, Caterpillar Tractor Co., Peoria, Ill.

Frank Shipley was appointed Chairman of the Program Committee, and Haydn Laycock, Chairman, Membership Committee.

After this meeting the officers met and laid plans for the first opening meeting of the group to be held during November. At this time there will be a technical speaker, and all those interested will be given a chance to sign the petition for the chapter.

The Association looks forward with pleasure to adding this new chapter to its rolls.

CHESAPEAKE CHAPTER
Pays Tribute to Admiral Van Keuren

MEMBERS of the A.F.A. Chesapeake chapter gathered at the Engineers Club, Baltimore, Md., on September 28 to honor Rear Admiral A. H. Van Keuren, Director of the Naval Research Laboratory, Washington, D. C. Over one hundred chapter members attended and witnessed the presentation of a certificate of Honorary Life Membership in A.F.A.

The award, authorized by action of the Board of Awards last January, was to have been presented to Admiral Van Keuren at the A.F.A. Annual Business Meeting held in Chicago July 18 and was made "in recognition of his efforts in behalf of the foundry industry." For many years the Naval Research Laboratory has worked closely with the foundry industry and its example of cooperation with industry has set high standards for other governmental agencies. Presentation of Honorary Life Membership was made in absentia at the July meeting and the certificate presented in person at the September 28 meeting of the Chesapeake chapter. Past President Lee C. Wilson, Reading, Pa., made the presentation.

The occasion was the chapter's National Officers' Night with Chapter Chairman Howard F. Taylor, Naval Research Laboratory, presiding. National President F. J. Walls, International Nickel Co., Detroit, discussed the necessity for foundry cooperation in the Association's program of educational work. He pointed out the great need for assuring a future supply of foundry manpower and urged the members to take an active interest in encouraging young men to enter the casting business.

Plans for the 50th Anniversary convention and exhibit of A.F.A. to be held in Cleveland next May, were outlined by National Secretary W. W. Maloney, Chicago. An open invitation was given all members of the Chesapeake chapter to attend the 1946 Annual meeting which, it is anticipated, will be held as an International Foundry Congress.

Technical speaker for the evening was Werner Finster, Reading Steel Castings Division, American Chain & Cable Co., Reading, Pa., on the subject of "Steel Foundry Sand Practice." The speaker was introduced by Technical Chairman and Chapter Vice-Chairman David Tamor, American Chain & Cable Co., York, Pa. Mr. Finster presented a number of interesting slides on steel foundry sand mixture and described the advantages and disadvantages attending the use of various sands and binders.

Considerable discussion and a number of questions followed the speaker's talk, indicating a lively interest in improving sand practice, not only in the steel but also in gray iron shops.

Buyers' Problems Are Discussed at New York

By G. Hadzima,
Robbins Conveyors, Inc.,
Passaic, N. J.

STATING three important questions that frequently arise in the buyers' dealing with foundries, R. V. Elms, Sperry Gyroscope Co. Inc., Brooklyn, N. Y., addressed the opening session of the Metropolitan chapter October 1. The meeting held at the Essex House, Newark, N. J., was presided over by Chapter Chairman H. A. Deane, American Brake Shoe Co., New York. Techni-

A chapter formation meeting held in Mexico City on October 6 was well attended by Mexican foundrymen. (Top—left to right)—Ing. Manuel Goicoechea, Herio Malleable de Mexico; N. S. Covacevich, Casa Covacevich; Ing. Ernesto Villalobos, Cia. Constructora de Marquinaria; Ing. Fernando G. Vargas, consultant; and R. L. McIlvaine, vice-president, National Engineering Co., Chicago.

National Officers' Night at the Chesapeake chapter. (Top left)—L. H. Denton and Ed Horlebein relax while Werner Finster and Max Kuniansky (top center) talk over a foundry problem. (Top right)—Admiral Van Keuren accepts his Life Membership in A.F.A. (Bottom, left to right)—Lee Wilson, A.F.A. Board of Awards Chairman; A.F.A. National Secretary Bill Maloney and guest speaker Werner Finster address the Chesapeake membership.

cal chairman for the evening session was Sam Tour, Sam Tour & Co., New York.

The three questions with which Mr. Elms dealt were: (1) Who is to pay for inspection jigs and gages required for the foundry's own inspection of the castings? (2) Who is to pay for castings rejected after machining? and (3) What time limitation can be placed upon the rejection of castings?

Don Reese, Campbell, Wyant & Cannon Foundry Co., Muskegon, Mich., spoke for the foundries and stated that the buyer should furnish inspection jigs required as they can make them cheaper than the foundry. When they are not supplied, the price of inspection fixtures should be figured in the selling price. The producer is basically responsible for the castings produced, however, work done on castings after leaving the foundry must be considered. Heat treatment may distort and crack castings. Improper machining by users is not chargeable to the foundry. The wholesale rejection of castings that have been stocked in the users plant for months is unfair to the foundry.

Alloys Are Stressed At Western Michigan

By R. W. Hathaway,
Federal Mogul Co.,
Greenville, Mich.

CHAPTER Chairman J. Wesley Lee, The Challenge Machinery Co., Grand Haven, Mich., presided over the October 8 meeting of the Western Michigan chapter held at the Hotel Schuler, Grand Haven, Mich. The technical session at this meeting was headed by George Watson, Electro Metallurgical Sales Corp., Chicago, who gave a very informative talk on the history and usage of ferro alloys. He outlined specific benefits derived by the use of alloys in the gray iron, steel and non-ferrous industries. Because the greater percentage of these alloys are imported, the speaker pointed out that the supply of alloys was maintained despite the shipping hazards encountered during the war.

Rockford Chapter Hears Foundry Education Plans

NATIONAL President F. J. Walls, International Nickel Co., Detroit, urged the Northern Illinois-Southern Wisconsin chapter to take greater interest in problems of future foundry personnel, in addressing a chapter meeting held September 11 at the Hotel Faust, Rockford, Ill., with chapter Chairman John R. Cochran, Sundstrand Machine Tool Co., Rockford, presiding. Fifty-eight foundrymen in the Rockford area heard President Walls discuss the importance of encouraging youths to consider the casting industry for a career.

The speaker emphasized the importance of chapter cooperation with local educational authorities to the end that the foundry industry can properly be presented as a business in which ingenuity and imagination offer many opportunities for young men. He described the success achieved by the Northeastern Ohio, Eastern Canada and Newfoundland and other A.F.A. chapters in interesting educational instructors and urged foundry supervisors to consider the value of apprenticeship and other training work.

Another speaker at the chapter's National Officers' Night was Na-

Part of the group that was present at the October 6 chapter formation meeting in Mexico City. (Left, insert)—A. Phillips Skinfield, Herio y Acero de Mexico. (Right, insert)—Otto F. Jagielski, Cia. Constructora de Marquinaria (left) and J. W. Schendel, La Consolidada, South America.

tional A.F.A. Secretary W. W. Maloney, Chicago, who called attention to the valuable literature that the Association has developed through the medium of its technical committees. He stated that the Association is constantly on the lookout for new committee "blood" and urged those interested to volunteer.

Chapter officers and directors, Canton District chapter, front row (left to right)—Chapter Secretary C. E. Shaw, American Steel Foundries, Alliance, Ohio; Chapter Vice-Chairman (West Area) C. F. Bunting, Pitcairn Co., Barberton, Ohio; Chapter Director Earl Brown, Union Metal Mfg. Co., Canton, Ohio; Chapter Director Charles Reyman, Jr., Atlantic Foundries, Akron, Ohio; and Chapter Director Charles W. McLaughlin, Barberton Foundry Co., Barberton, Ohio. The back row (left to right)—Chapter Vice-Chairman (Central Area) I. M. Emery, Massillon Steel Castings Co., Massillon, Ohio; Chapter Director H. E. McKimmey, Carnegie-Illinois Corp., Canton, Ohio; Chapter Director C. B. Williams, Massillon Steel Castings Co., Massillon, Ohio; Chapter Treasurer O. D. Clay, Tuscora Foundry Sand Co., Canal Fulton, Ohio; Chapter Director Charles Scoville, Babcox & Wilcox Co., Barberton, Ohio; and Chapter Director F. C. Glass, The Demming Co., Salem, Ohio.

Consumer Cooperation Holds Chicago Interest

By L. C. Smith,
Peninsular Grinding Wheel Co.,
Chicago

AN economist of note, Harland H. Allen, Harland Allen Associates, Chicago, addressed the Chicago membership at their first regular meeting on "Consumer Cooperation." The session was held October 1 at the Chicago Bar Association.

Gitzen Addresses Twin City on Core Problems

By Paul Hesse,
Union Brass & Metal Mfg. Co.,
St. Paul, Minn.

THE first meeting of the Twin City chapter was held at the Curtiss Hotel, Minneapolis, September 19, with Joe Gitzen, Delta Oil Products Co., Milwaukee, as the guest speaker. Chapter Chairman Bob Wood, Minneapolis Electric Steel Castings Co., Minneapolis, presided and introduced the speaker.

The first phase of Mr. Gitzen's address was a discussion of the various types of core binders and the general core problems associated with them. He grouped the various types of core binders into the organic and inorganic. It was pointed out that the organic binders burn and produce gas at the temperature of molten metal, while the inorganic binders are inert at elevated temperatures and produce no gas. The speaker discussed each binder in detail, special consideration being given to green strength, hot strength, collapsibility, decomposition temperature, gas ratio, baking rate and moisture absorption.

The second phase of the lecture had to do with core washes. It was noted that a core wash has a number of functions to perform and include: close voids at the core surface; prevent contact between metal and core sand; raise the fusion point of sand at the core surface; reinforce surface grains to limit movement due to thermal expansion; and form an envelope around the core to prevent core gas penetrating the metal.

Central Ohio chapter members enjoying the outing held at the Brookside Country Club, Columbus, Ohio.

Solidification Talk at Cleveland by Schwartz

By Pat Dwyer,
Penton Publishing Co.,
Cleveland

APPROXIMATELY 150 members and guests attending the October 11 meeting of the Northeastern Ohio chapter, at the Tudor Arms Hotel, heard two speakers discuss widely different subjects in a highly interesting and informative manner. Harry T. O'Connor, special agent in charge of the Cleveland office of the Federal Bureau of Investigation, talked on the FBI's experience in preventing a serious attempt at sabotage in the early days of the war. Dr. H. A. Schwartz, manager of research, National Malleable & Steel Castings Co., Cleveland, presented a scholarly and scientific discussion on "Solidification of Metals."

In the intermission period chapter president A. C. Denison, Fulton Foundry & Machine Co., Cleveland, announced that the membership of the chapter continues to increase in a gratifying manner.

The lecture by Dr. Schwartz, illustrated by many slides and dealing with the scientific principles underlying the solidification of metal, was a condensation or abridged version

(Photos courtesy Sterling Farmer, Sand Products Corp.)

Northeastern Ohio chapter meeting held October 11 at the Tudor Arms Hotel, Cleveland.

of the Third Annual Foundation Lecture sponsored by the American Foundrymen's Association.

Correct Foundry Waste Quickly Advises Edgar

By B. P. Mulcahy,
Citizens Gas & Coke Utility,
Indianapolis

SUBJECT discussed by A. J. Edgar, technical advisor, Gray Iron Founders' Society, Washington, D. C., on October 1 before the Central Indiana chapter at Indianapolis, was "Correcting Waste in the Foundry."

Mr. Edgar pointed out initially that in 1944 the production of gray iron was only half of its potential capacity and that the waste attendant with the process was a serious handicap to the industry. The problem of correction was broken down into several factors, the most important of which was the cupola. This factor was discussed at length, detailing its operation and highlighting the points which contribute to waste of materials in both quality and quantity. The composition of cores, sand handling and conditioning, gating and risering, and patterns were all briefly discussed in their responsibility of waste. In conclusion it was emphasized that the future of the industry depended upon the production of sound castings, the accomplishment of which required the elimination of much of the waste now prevalent.

George Clark, metallurgist, Cummins Engine Company, Columbus, Ind., served capably as Technical Chairman of the meeting.

E. H. Schleede (second from left), U. S. Gypsum Co., Chicago, was the guest speaker at the October 9 meeting of the Rochester chapter. Others in the picture are (left to right) W. G. Brayer, chapter board member and program chairman, Bausch & Lomb Optical Co.; W. F. Morton, chapter chairman, The Anstice Co., and M. T. Ganzauge, chapter board member, General Railway Signal Co.

Schleede Meets With Rochester Foundrymen

By D. E. Webster,
American Laundry Machinery Co.,
Rochester, N. Y.

THE Rochester chapter opened its 1945-46 season at the Hotel Seneca on October 9. M. T. Ganzauge, General Railway Signal Co., a member of the chapter's board of directors, gave a few highlights of his recent experiences in Europe, where he was sent to investigate certain phases of the foundry industry.

The speaker for the evening was E. H. Schleede, U. S. Gypsum Co., Chicago. He presented a story on the use of cements in the foundry and pattern shop. With the aid of a sound slide picture, together with practical demonstrations, Mr. Schleede made clear the details of good practice in the use of these materials. The various cements are finding wide use today for the making of some intricate patterns that must be held to close tolerances.

Professional Engineers Meet With Canton Men

By N. E. Moore,
Wadsworth Testing Laboratory,
Canton, Ohio

THE Ohio Society of Professional Engineers, Canton chapter, were the guests of the Canton District chapter at its first meeting of the year at Mergus Restaurant with an attendance of 122 men.

(Continued on Page 82)

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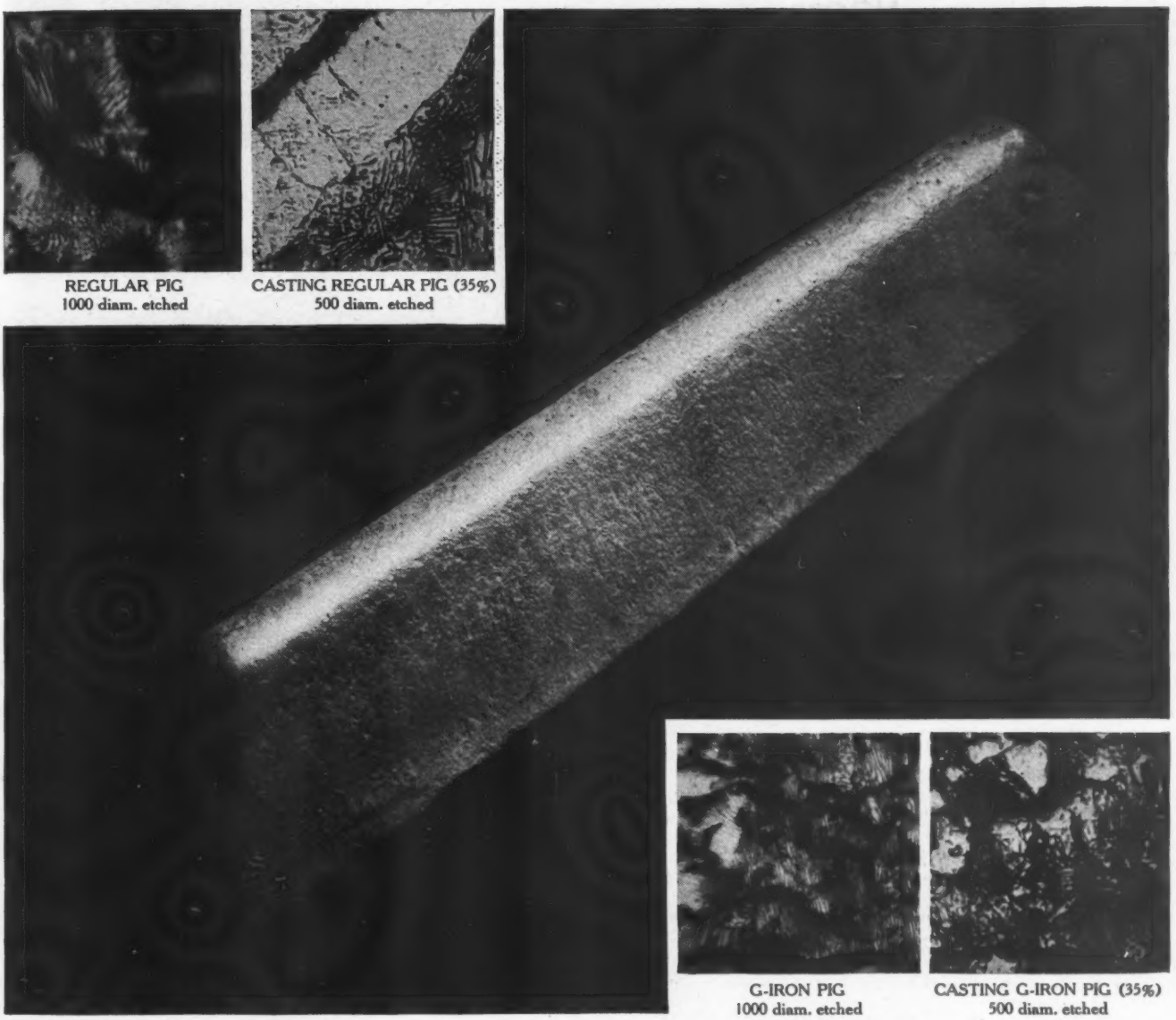

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1000 diam. etched

CASTING G-IRON PIG (35%)
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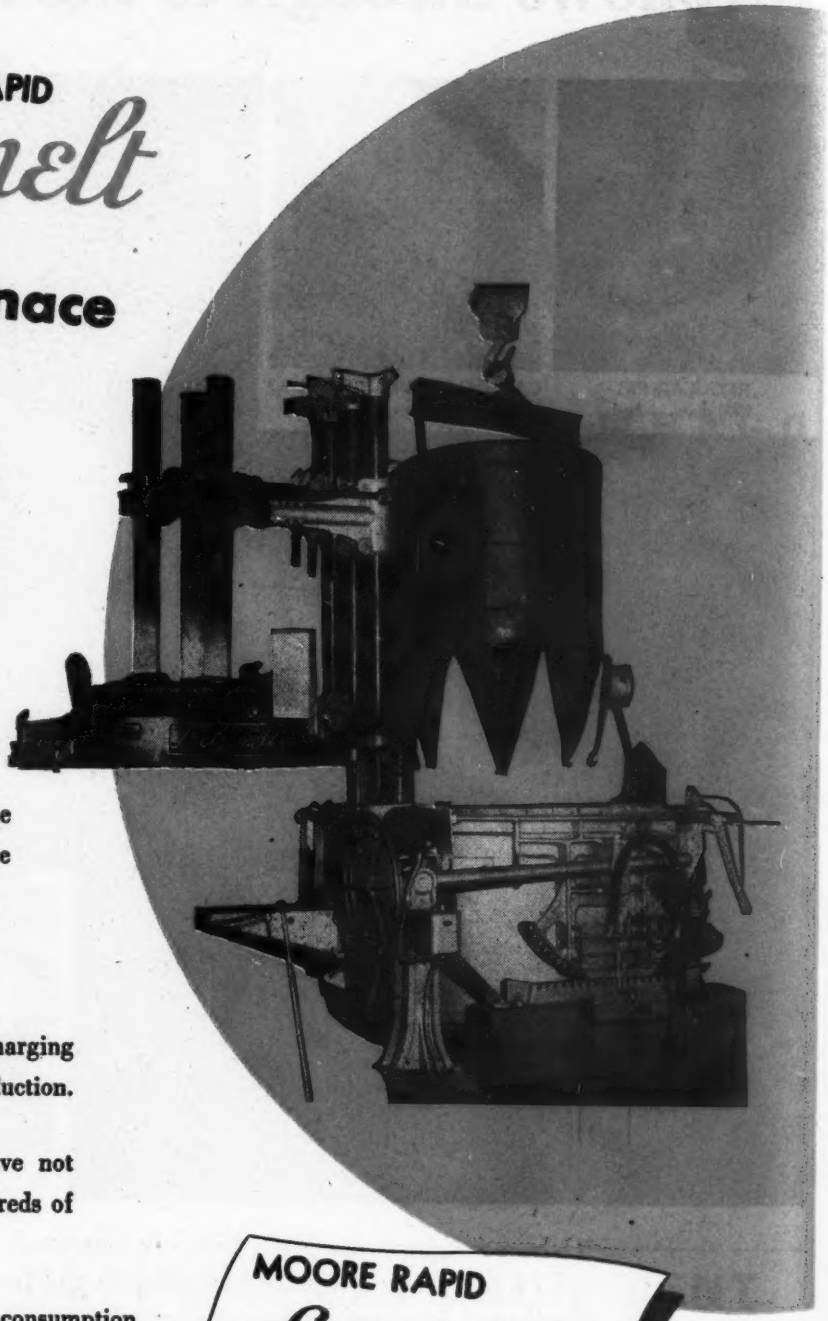

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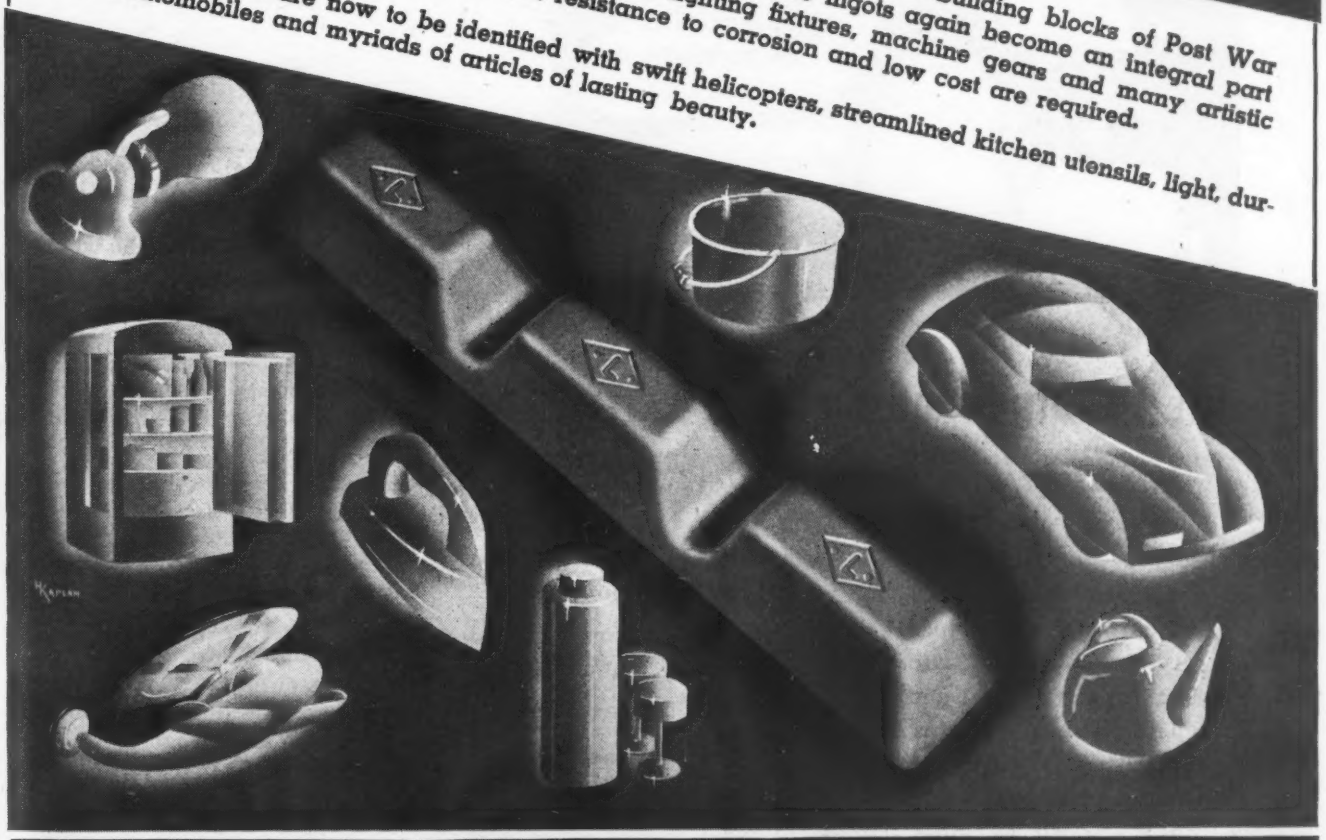

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REPRESENTATIVES IN PRINCIPAL CITIES

CHAPTER ACTIVITIES

(Continued from Page 76)

Conrad Trout, manager, Vocational Training Department, Hoover Co., gave the first of five coffee talks on "Job Evaluation."

Speaker of the evening was J. A. Rassenfoss, supervising engineer, research laboratories, American Steel Foundries, Chicago. He chose as his subject "Some Notes on the Manufacture, Design and Engineering Applications of Castings." Problems encountered in producing sound castings were illustrated and methods of dealing with them were described. Inclusions and their effect on physical properties were discussed.

Ridderhof on Facings Before Michiana Group

By H. B. Voorhees,
Dodge Mfg. Corp.,
Mishawaka, Ind.

ON October 2 at the Hotel Whitcomb, St. Joseph, Mich., the Michiana chapter was privileged to have as their speaker Dr. J. A. Ridderhof, manager, Foundry Facing Department, Frederic B. Stevens, Inc., Detroit. W. V. Johnson, Oliver Farm Equipment Co., South Bend, Ind., Chapter Chairman, presided.

Dr. Ridderhof addressed the membership explaining the use of such facings as graphite and rosins, and how they should be used to achieve best results. He also stressed the best procedure to use when facing molds and cores of various sizes; the proper temperature to use to dry facings and other important factors.

Philadelphia Chapter to Continue Lecture Course

AN elementary foundry lecture course sponsored by the Philadelphia chapter was started on November 5. This 18 week course is tuition free and is held in the University of Pennsylvania's Engineering Building every Monday evening. Lectures will be presented by well known foundry metallurgists and engineers on non-ferrous, cast iron, malleable iron and steel subjects.

Central Ohio Outing Pleases Vast Crowd

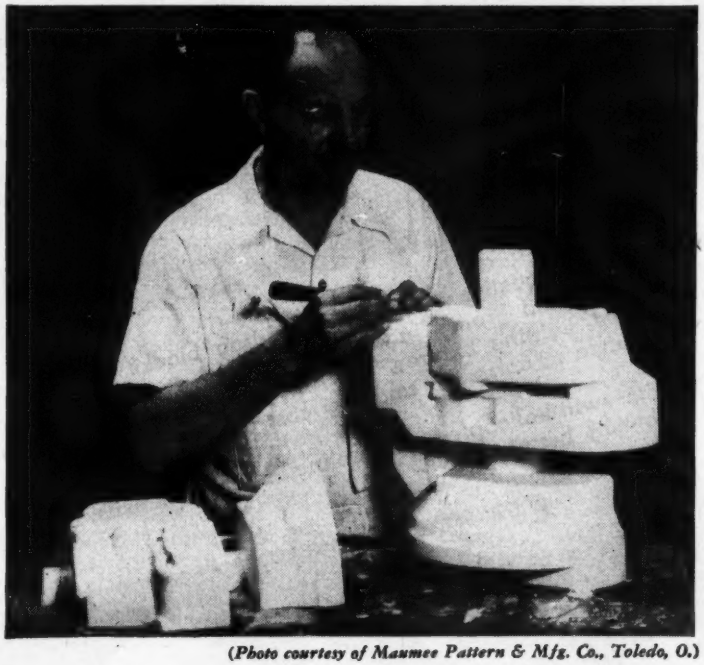
By Karol Whitlatch,
Aetna Fire Brick Co.,
Oak Hill, Ohio

THE first annual outing of the Central Ohio chapter, held recently at the Brookside Country Club, Columbus, Ohio, was a big success. Over 200 men spent a day golfing, bait casting, shooting darts, pitching horseshoes and enjoying an afternoon of relaxation. During the dinner, prizes were awarded for the competitive sports. A floor show followed the meal.

Stigers Relations Talk Stresses Human Research

By Lee H. Horneyer,
St. Louis

DIVIDING his talk on "Human Relations in the Foundry" into three classes: (1) Employee Interest, (2) Race Prejudice and (3) Foreman's Unions, M. F. Stigers, Associate Professor, Purdue Univer-



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sity, Lafayette, Ind., addressed the October meeting of the St. Louis District chapter at the DeSoto Hotel.

Professor Stigers stressed the need of employers investing as much for research in improving human relations as was spent for research on improved methods and equipment.

Reference was made also to strive for better cooperation between employer and employee, with both sides needing understanding and sympathy for one another.

Foundry Modernization Is Topic of Northeastern Ohio

OVER 175 members and guests of the Northeastern Ohio chapter turned out for National Officers' Night, September 13, held at the Cleveland Club, Cleveland. Chapter Chairman A. C. Denison, Fulton Foundry & Machine Company, presided.

Featuring the dinner meeting was a talk by National A.F.A. President F. J. Walls, International Nickel Co., Detroit, who described briefly some developments in foundry practices during the past ten years. President Walls then stated that the foundry of the future would be dependent largely on solution of the industry's present manpower problems. "No industry can grow," he said, "without assuring itself of a constant influx of younger men, both trained and untrained."

"To guaranty a supply of young blood for the future of the foundries is perhaps the most important problem facing the industry today."

President Walls, at the conclusion of his talk, presented certificates of award and cash prizes to two winners in the 1945 National Apprentice Contest. One award went to Robert Cech of the Cleveland Trade School for earning second prize in the Pattern Making contest; the other to Steve Grabowski of the Cleveland Trade School for second prize in Gray Iron Molding. President Walls pointed out that Robert Cech is a son of Frank Cech, long associated with the Cleveland Trade School and an active member of the Northeastern Ohio chapter.

Plans for the 50th Anniversary and convention exhibit of A.F.A., to

(Continued on Page 89)

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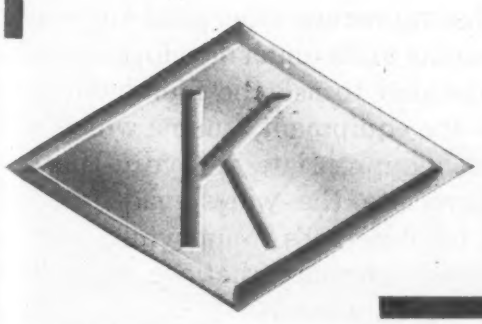

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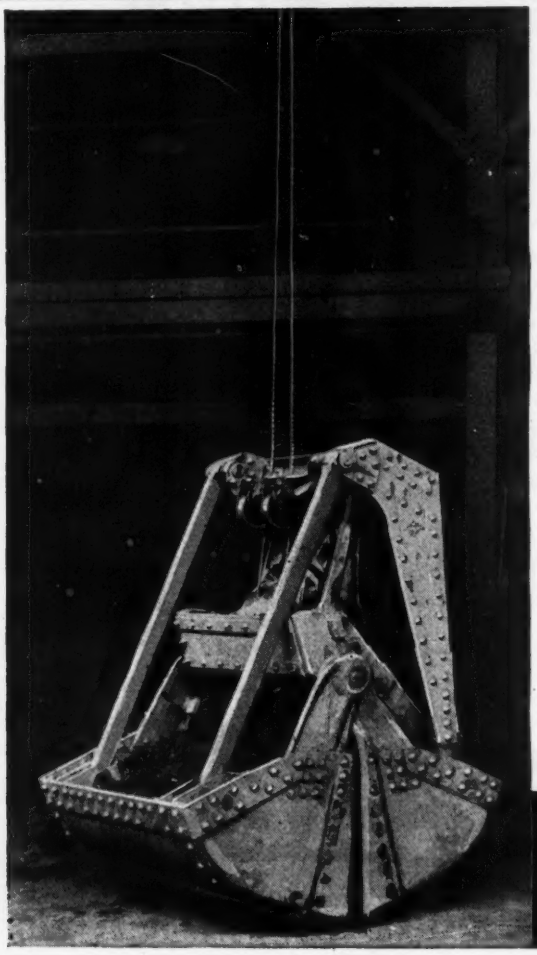

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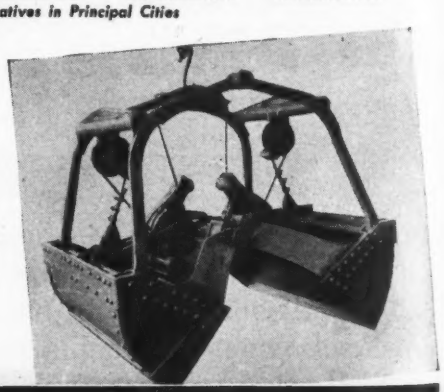

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CHAPTER ACTIVITIES

(Continued from Page 83)

be held in Cleveland next May, were announced by National A.F.A. Secretary W. W. Maloney. He announced the formation of local convention committees and stated that the Association was anticipating that the 1946 convention would be held as an International Foundry Congress, and that it would prove to be the most important event of its kind ever staged for the foundry industry.

Following the dinner session, Chapter Vice-Chairman H. J. Trenkamp, Ohio Foundry Co., Cleveland, presided as Chairman of the Program Committee. Mr. Trenkamp introduced as guest speaker L. B. Knight, Lester B. Knight & Associates, Chicago, who spoke on the subject of "Foundry Modernization." Mr. Knight developed his subject from several fundamentals of engineering practices, including organization, costs, methods and facilities, stating that their importance ranks in that order.

Illustrating his talk with slides of foundry installations, the speaker created great interest in practical means for operating an efficient foundry at low cost.

Dietert Speaks Before New England Association

By Merton A. Hosmer, President, New England Foundrymen's Association, Boston

THE monthly meeting of the New England Foundrymen's Association was held at the Engineer's Club, Boston, on October 10. There were one hundred and sixty members and guests present. The Non-Ferrous Foundrymen's Association of New England were special guests of the evening. Justin A. Duncan, president, Non-Ferrous Foundrymen's Association addressed the meeting briefly immediately following the dinner.

The speaker of the evening, H. W. Dietert, Harry W. Dietert Co., Detroit, spoke on "Improvement of Casting Surfaces Through Molding Sand and Core Mixture Control." Mr. Dietert showed the affect of mold atmosphere on the surface of the casting produced. He stated

(Continued on Page 90)

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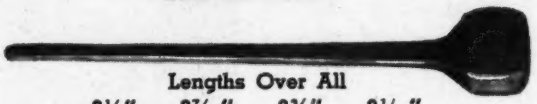

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CHAPTER ACTIVITIES

(Continued from Page 89)

that up until recently the amount of gas pressure in a mold was considered of little importance, but that considerable work had recently been done on this subject because of the fact that methods of testing for gas pressure had been perfected. Through colored motion pictures, gas activity in the mold, and its effect on the casting finish, was clearly brought out. He stated that the recent attention to casting finish was attributed, in part to the tendency of many companies to substitute stamped parts for castings because of the lower cost of the former.

Mr. Dietert stated that in his opinion the foundry industry spent less time and money on research than any other industry. He suggested that foundries who would be willing, in the future, to set aside a molder and molding machine for research and development would not only find it paid big dividends but that many an argument would be settled to the satisfaction of the foundrymen through this means. All foremen look to the possibility of becoming foundry superintendents and are desirous of obtaining as much knowledge of foundry practices and developments as possible, and look with great favor on the research floor as a means to this end.

He called attention to the necessity for an accurate ramming machine in testing for strength of a molding sand and stated that the accuracy of this test depended on the accuracy of the rammer. He called attention to the necessity of accurate moisture control in the sand as a means of recommending gas pressure.

Connecticut Organizes A Cleaning Castings Forum

By L. G. Tarantino, Secretary, Connecticut Non-Ferrous Foundrymen's Association, New Haven, Conn.

MEMBERS of the Connecticut Nonferrous Foundrymen's Association met at Indian Hills Country Club, New Britain, Conn., September 18 for a round table discussion. The topic was "Cleaning

(Continued on Page 92)

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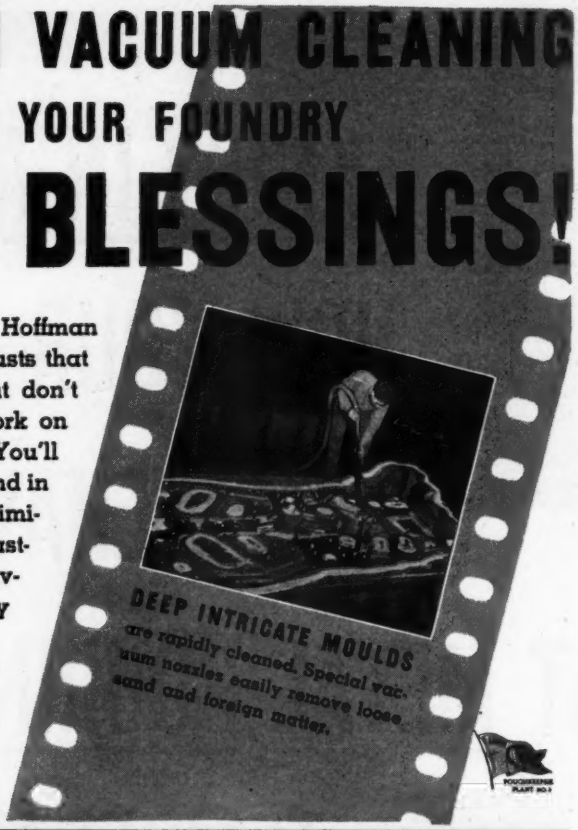

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CHAPTER ACTIVITIES

(Continued from Page 90)

of Castings" and the topic was divided into six sections. In this manner those present heard the discussion leaders give data on every phase of casting cleaning known to the industry.

Management in Rockford Discusses A.F.A. Work

TOP management of a number of foundries in the A.F.A. Northern Illinois-Southern Wisconsin chapter area met September 11 at the Hotel Faust, Rockford, Ill., at a luncheon session sponsored by the Management Committee of the National A.F.A. Board. Held in conjunction with the A.F.A. chapter, the meeting was devoted to present and future problems of the foundry industry, especially along educational and manpower lines.

D. P. Forbes, Gunite Foundries Corp., Rockford, presided as a past President of A.F.A. and a past chairman of the N.I.-S.W. chapter. National President F. J. Walls, International Nickel Co., Detroit, stressed the stake that foundry management has in the activities of the Association and urged the executives present to take greater interest in local efforts to stimulate interest in foundry work.

Mr. Walls stated that the average age of experienced molders is so advanced today that the industry must give serious thought to developing and training young men for the foundry business. "The problem is not only that of reaching into the engineering schools and colleges," he said, "but also to develop interest among boys in the high schools and even the grade schools if the foundry industry is to be assured in the future of a continuous flow of dependable manpower."

Following Mr. Walls' talk, considerable interest was indicated in a program of cooperation between the N.I.-S.W. chapter and Rockford educational authorities. It is hoped that such cooperation can develop greater interest in foundry work and finding opportunities among the instructors and students in local technical schools.

Chairman Forbes and Chapter Chairman John R. Cochran, Sund-

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strand Machine Tool Co., Rockford, described activities of the Association and the local chapter on behalf of foundry employees. Some of the A.F.A. activities of direct benefit to foundry workers and their companies were described by National A.F.A. Secretary W. W. Maloney, Chicago. Particular emphasis was placed on committee work as a means of acquiring greater knowledge on many phases of modern foundry practice.

Twin City Publishes Membership Directory

RECOGNIZING the fact that publicity within an organization is as important as publicity outside the organization, the Twin City chapter recently published the first edition of a membership directory. Included are brief histories of the American Foundrymen's Association and the Twin City chapter, as well as a tabulation of officers, directors and committees, the 1945-46 program and the dues structure. One listing shows the home addresses, position and company affiliation of every member. Listed under every company represented in the membership are the company address, class of membership held and the individuals in the company who belong to A.F.A.

Central Indiana Joins Engineering Societies

THE Engineering Societies of Central Indiana have formed an Indianapolis Technical Societies Council. The A.F.A. Central Indiana chapter has been interested in cooperating in this promotion, and representatives of the chapter on the Indianapolis Technical Societies Council are Past Chapter Chairman Harold H. Lurie, Cummins Engine Co., Columbus, Ind., and present Chapter Chairman, Ray S. Davis, National Malleable & Steel Castings Co., Indianapolis.

A number of these Technical Societies Councils have formed in many of the leading industrial centers, with the A.F.A. chapters taking an active part.

WELL-FED *Castings*
MEAN BETTER *Castings!*

FEEDOL*
A feeding compound for Non-Ferrous Alloys

*A FOSECO Product

Get the advantages of "riser-feeding"—keep metal liquid longer—reduce size of risers. Get more castings per melt, less remelt. For use with aluminum, manganese and silicon bronzes, tin bronzes, brass and nickel alloys.

Write for samples, make your own test.

FOUNDRY SERVICES, INC.
280 Madison Avenue
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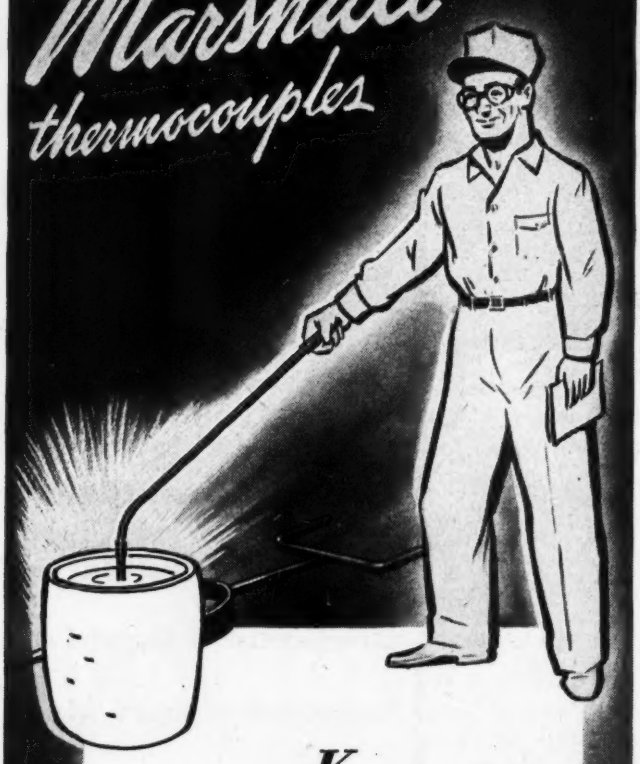
Check Temperatures Quickly with

Marshall thermocouples



KNOW your pouring temperatures!" This has become the foundryman's first principle! He finds that overheating and underheating of nonferrous metals can cause costly spoilage, "upping" all his operating costs.

The use of Marshall Enclosed-Tip Thermocouples assures real production economy. Using these Thermocouples, you can check temperatures of molten brass, bronze, aluminum and magnesium quickly,—and temperature readings can be depended upon as correct!

In the use of Thermocouples, only the instrument that assures accuracy is really economical.

L. H. MARSHALL CO.

270 W. Lane Ave. Columbus 2, Ohio

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POURING GRAY

Here's why

VELSICOL *Coresin* OIL WILL SERVE YOU *better*

As Gray Iron is the biggest single unit in the foundry industry, and still growing, the chances are better than even that you *are* pouring this metal. Add to this, that "Gray Iron is the most complex alloy in the whole family of iron and steel alloys", and you have a picture, that makes the problems of the A-Bomb look simple.

CORE OILS are our business. We've made a study of what *type of oils* are best suited to the production of cores for Gray Iron castings. VELSICOL chemists, engineers, and practical foundrymen have pooled their knowledge to make Core Oils that will work best with Gray Iron. The CORESIN content of VELSICOL OILS imparts good surface hardness and sharp edges to the cores; ample resistance to heat gives balanced cores enough toughness to withstand pouring heat, and yet collapse when they should, and clean readily. However, we won't bore you with a catalog of VELSICOL CORESIN OIL'S virtues. Suffice it to say that we have developed oils which for *Uniformity, Dependability* and *Serviceability* meet the need of Gray Iron Foundrymen for more efficient output and improved quality control.

Lest our friends in other categories feel slighted, we hasten to say that VELSICOL specializes in good Core Oils for *all* metals, both ferrous and non-ferrous; and for those preferring a light color oil, VELSICOL offers its SERIES B OILS. Tell us today what metals you pour, and we'll be glad to submit working samples of the correct oils and complete data. Write or call us or the representative in your territory.

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Manufacturers of Coresin Core Oils · Aromatic Solvents Synthetic Resins · Insecticides

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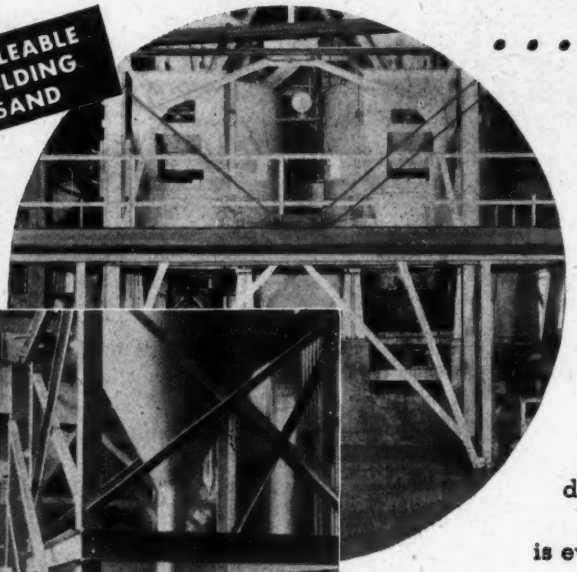
SIMPSON Intensi MIXERS

. . . better sand preparation for every foundry application

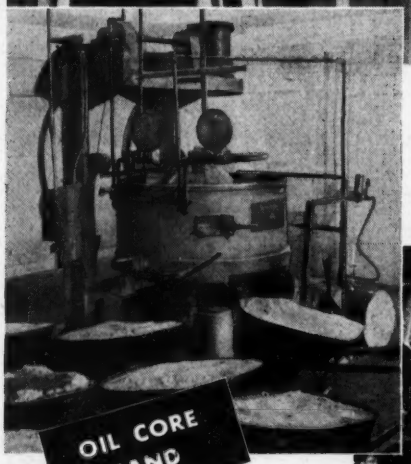
. . . . . proved on the Job!

MALLEABLE MOLDING SAND



Two No. 3 Unit Drive Simpson Mixers in large midwestern malleable plant where all sand is mulled and processed in system prior to each use.

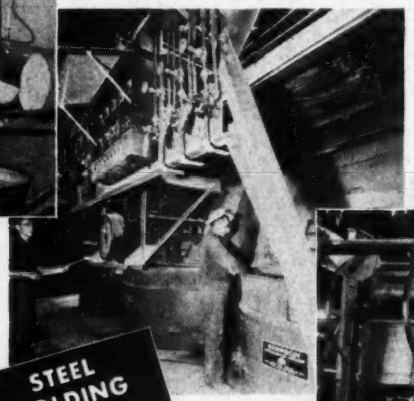
NON-FERROUS MOLDING SAND



(Above) No. 2 Unit Drive Simpson Mixer installed in a west coast brass plumbing goods foundry where extremely accurate sand molding is necessary. The rapid growth of aluminum and magnesium foundries, has resulted in the increased use of synthetic sand in these foundries . . . and the Simpson Mixer has been proved the best method of conditioning non-ferrous molding sand.

OIL CORE SAND

No. 1½ Unit Drive Simpson Mixer in medium sized core room. Served by National Loader and liquid meters for oil and water additions.



STEEL MOLDING SAND

Battery of three No. 3 Unit Drive Simpson Mixers in system of large Pacific coast steel foundry. Note that mixers are completely controlled by National Time-Masters and loaded by means of a traveling batch hopper.

GRAY IRON MOLDING SAND

No. 1½ and No. 2 Unit Drive Simpson Mixers equipped with National Loaders and Aerators preparing synthetic facing and heap sands for specialized gray iron foundry.

IN EVERY BRANCH of the foundry industry, Simpson Mixers are proving their worth. Thousands are already in use and four out of every five new mixers sold today are Simpsons.

Here indeed, in the overwhelming preference of the men who use them, is proof . . . that a Simpson is your best bet for *every* foundry application . . . that the Simpson principle of "mulling" results in the uniform distribution of bond and sand so necessary to produce perfect castings. Here also, is evidence that the Simpson statement about mixing faster, and with less expense is a fact, proved by Simpsons on the job . . . producing more, better conditioned sand at the lowest net cost per ton.

Product of a practical foundryman, improved and perfected throughout National's 30 years of service and experience in the foundry industry, built honestly and well for a long service life, protected by a competent staff of field service men . . . this Simpson Mixer is truly a wise investment for every foundry sand preparing application.

ARMY E NAVY

And now—a second white star has been added to our Army-Navy Production Award Flag—for continued production achievement.

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A.F.A. Golden Jubilee

1896 1946

CLEVELAND

May 6-10, 1946

A.F.A celebrates its 50 Anniversary as the foundry industry begins its first year of peace-time production! A.F.A., therefore, has a two-fold reason for making the 1946 Foundry Congress and Foundry Show, Cleveland Auditorium, an event that long will be remembered in the historic annals of the metal castings field.

The National Office in Chicago is whipping into shape the multitude of plans dictated by the A.F.A. Board of Directors. Program and Paper Committees of all A.F.A. Divisions are putting the finishing touches on the different series of Technical Sessions so that visiting foundrymen from far and near can benefit from the pooling of technical knowledge that will be of such help to the foundry field in this post-war era of competition.

Exhibit plans include the use of all Exhibit Halls in the Cleveland Auditorium to help manufacturers show their products to best advantage. The value of National Industrial Expositions has been proved many times, and the Foundry Exhibit is no exception. With most war-time restrictions removed, exhibitors will find this A.F.A. 50 Anniversary Convention the ideal opportunity for displaying New Developments and the Latest Foundry Equipment to a waiting and responsive audience.

50

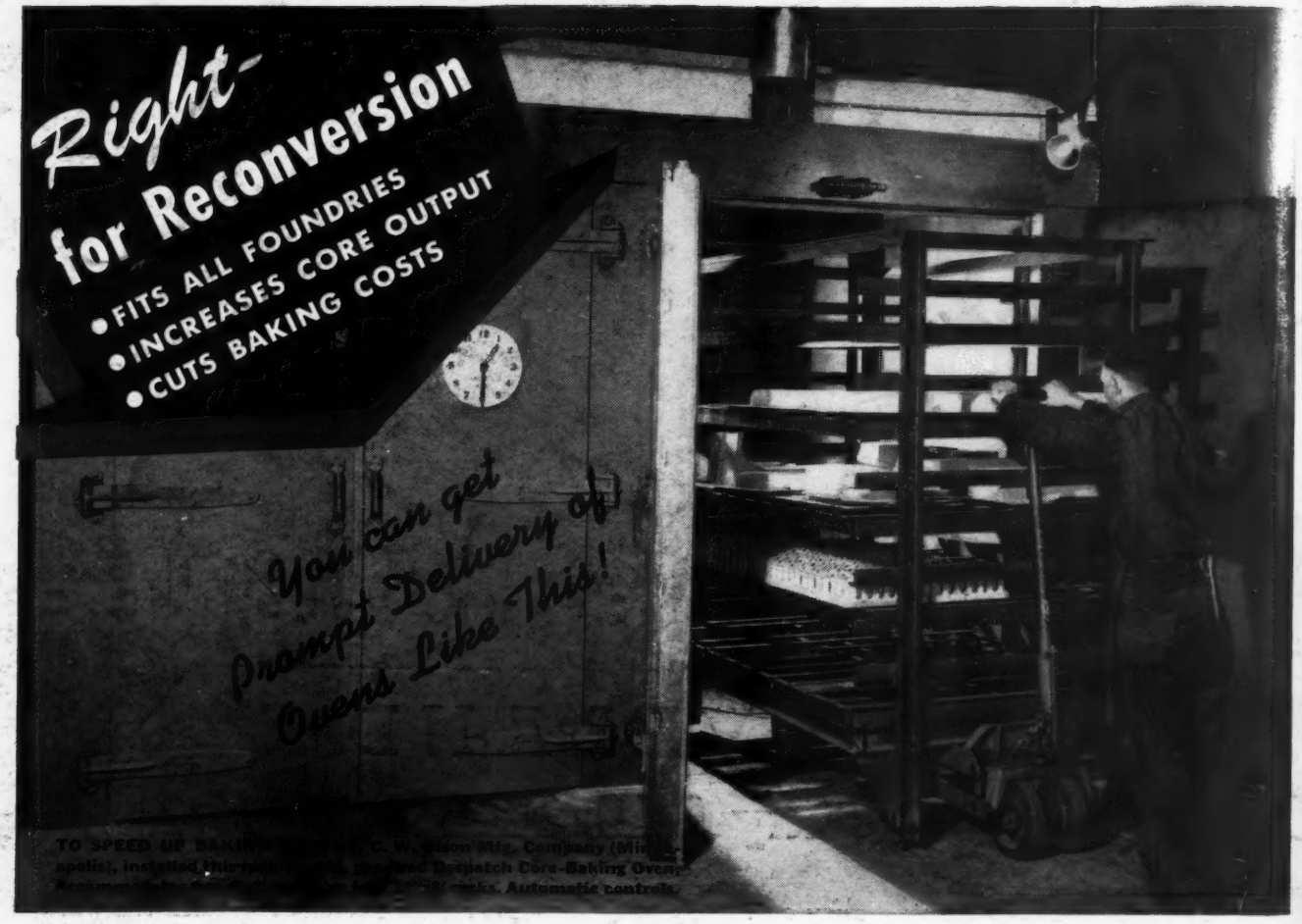
Years of Progress and Foundry Service

Under the guidance of the Northeastern Ohio Chapter, the social aspects of a typical but greatly expanded A.F.A. Congress appear destined to set new records. Long established as the ideal meeting ground for men engaged in a common cause—**the development and production of better castings**—this greatest of all A.F.A. Conventions will cement new friendships that will result in a greater industry, united behind the guiding influence of the American Foundrymen's Association.

Complete details of developments for the 50 Anniversary Meeting will appear in the pages of the AMERICAN FOUNDRYMAN, official publication of the American Foundrymen's Association. Watch the pages of this "Foundrymen's Own Magazine" for the latest news of the 1946 Foundry Congress and Foundry Show, May 6-10, Cleveland, Ohio.

American Foundrymen's Association

222 WEST ADAMS STREET CHICAGO, ILLINOIS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for Reconversion
• FITS ALL FOUNDRIES
• INCREASES CORE OUTPUT
• CUTS BAKING COSTS
You can get Prompt Delivery of Ovens Like This!

DESPATCH BATCH TYPE CORE-BAKING OVENS

IF YOURS IS A TYPICAL FOUNDRY after new business, more customers, extra profit . . . then here's a Despatch Core-Baking Oven that will help you do the job right.

What's more, you can get a rugged, compact, fast-baking oven like this delivered and installed promptly!

DOUBLES OUTPUT, ELIMINATES REJECTS

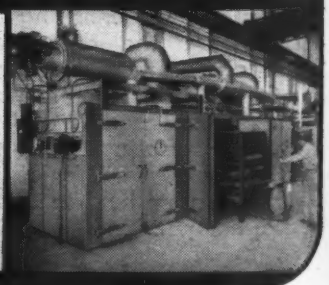
Typical of the results *you* can expect, this Despatch Oven replaces two bulky older ovens, and increases previous baking capacity . . . bakes large and small cores at same time . . . banishes stink of non-ferrous binder fumes . . . and has eliminated all rejects due to faulty baking.

ORDER NOW FOR PROMPT DELIVERY!

Get speedy installation of a Despatch Batch Oven for boosting output and cutting overhead costs. Adds to your profits. All types, all sizes, all fuels; fully guaranteed.

DESPATCH CAR-LOADED OVEN for baking large molds or cores. Handles 10 tons per charge in chamber 23 ft. long, 13 ft. wide, 8 ft. high. Combination Despatch gas or oil-fired heater.

DESPATCH RACK-LOADED OVENS, gas-fired. Available in 64 standard models and built to handle cores of all sizes. Panel construction allows low cost alteration or expansion. Ruggedly built.



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